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C.3 Stormwater Technical Guidance

May 29, 2012

A handbook for developers, builders and project applicants

Version 3.1

Protecting Alameda County Creeks, Wetlands & the Bay

Updates and Errata

The following changes were made since Version 3.0 was published in December 2011.

#1 – Deleted May 2012

Table 2-1 (Projects Excluded from Provision C.3 Requirements)

#2 – Added May 2012

A new revised Table 5-3 (Projects Excluded from Provision C.3 Requirements)

#3 – Deleted May 2012

Portions of Section 5.1 (Hydraulic Sizing Criteria)

- The entire subsection titled “Combination Flow and Volume Design Basis”
- Table 5-3 (Estimated Runoff Coefficients for Various Surfaces During Small Storms)

#4 – Added May 2012

Portions of Section 5.1 (Hydraulic Sizing Criteria)

- A new revised subsection titled “Combination Flow and Volume Design Basis”
- A new revised Table 5-3 (Estimated Runoff Coefficients for Various Surfaces During Small Storms)

#5 – Deleted May 2012

Text in Section 6.9 (Green Roofs):

- The planting media shall be a minimum of 3-inches deep and shall have sufficient depth to provide capacity within the pore space of the media to capture 80 percent of the average annual runoff.

#6 – Added May 2012

Text in Section 6.9 (Green Roofs):

- The green roof system planting media shall be sufficiently deep to provide capacity within the pore space of the media to capture 80 percent of the average annual runoff.

#7 – Deleted May 2012

Appendix C (Example Scenarios)

#8 – Added May 2012

New version of Appendix C (Example Scenarios)

#9 – Deleted May 2012

Figure J-1 (Flow chart of feasibility and infeasibility evaluation process) in Appendix J

#10 – Added May 2012

Revised Figure J-1 (Flow chart of feasibility and infeasibility evaluation process) in Appendix J

#11 – Deleted May 2012

Text in Step 3.a. of Section J.1 (General Approach) in Appendix J

- , if the applicant meets the requirement, described in Appendix K, to document that LID treatment is infeasible.

#12 – Deleted May 2012

Text in Section J.2 of Appendix J (Feasibility Evaluation: Infiltration and Rainwater Harvesting/Use)

- The entire subsection titled "Special Projects Prescreening"

#13 – Added May 2012

Text in Section J.2 of Appendix J (Feasibility Evaluation: Infiltration and Rainwater Harvesting/Use)

- A new revised subsection titled "Special Projects Prescreening"

#14 – Deleted May 2012

Worksheets in Appendix J (Feasibility Evaluation: Infiltration and Rainwater Harvesting/Use)

- Screening Worksheet
- Infiltration Feasibility Worksheet
- Rainwater Harvesting and Use Feasibility Worksheet
- Special Projects Worksheet

#15 – Deleted May 2012

Text in Section K.1 (Introduction) of Appendix K (Special Projects)

- As described in Section K.5, documentation must be provided to show why the use of LID treatment is considered infeasible.

#16 – Added May 2012

Text in Section K.1 (Introduction) of Appendix K (Special Projects)

- As described in Section K.5, documentation must be provided to discuss the feasibility and infeasibility of using 100 percent LID treatment onsite and offsite.

#17 – Added May 2012

New Section K.6 (Select Non-LID Treatment Measures Certified by a Government Agency) of Appendix K

- The new section advises that non-LID treatment measures that are allowed in Special Projects should be certified by the Washington State Department of Ecology's Technical Assessment Protocol – Ecology (TAPE) program.

Local Contacts

Please contact the local agency with any questions regarding requirements specific to the local jurisdiction, using contact information provided below.

Alameda: Public Works Department, 510.749.5840

Albany: Community Development and Environmental Resources Department 1000 San Pablo Avenue, Albany, CA 94706. 510.528.5760

Berkeley: 510.981.7451

Dublin: 925.833.6650

Emeryville: Civic Center, 1333 Park Ave, Emeryville, CA 94608
510.596.3728, www.ci.emeryville.ca.us/planning/stormwater.html

Fremont: Environmental Services Division, 39550 Liberty Street, Fremont CA 94538, 510.494.4570, www.fremont.gov/stormwaterdevelopment

Hayward: Engineering and Transportation Division, 510.583.4785

Livermore: 925.960.8100 (Inspection/reporting), 925.960-4500 (C.3 Technical Info)
Permit Center, 1052 South Livermore, Ave. Livermore, CA 94550

Newark: Michael Carmen or Soren Fajeau, City Hall – Public Works, 37101 Newark Boulevard, 1st Floor, Newark CA 94560, 510.578.4320

Oakland: Permit Center, 250 Frank H. Ogawa Plaza, 2nd Floor, Oakland, CA 94612
510.238.3911, www.oaklandnet.com

Piedmont: Public Works Counter, City Hall, 120 Vista Avenue, Piedmont, CA 94611; 510.420.3050; www.ci.piedmont.ca.us

Pleasanton: Utility Engineer, 925.931.5508

San Leandro: Engineering and Transportation Department, Civic Center- 835 East 14th Street, San Leandro, CA 94577
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Union City: 34009 Alvarado-Niles Blvd., Union City, CA 94587, 510.675.5362

Unincorporated Alameda County: 510.670.5543
339 Elmhurst Street, 1st Floor, Permit Center, Hayward, CA 94544

Alameda County Flood Control and Water Conservation District: 510.670.5543
339 Elmhurst Street, 1st Floor, Permit Center, Hayward, CA 94544

Zone 7 Water Agency: 925.454.5036

Credits

The Clean Water Program extends its appreciation to all those who contributed to this document, which was developed under the guidance of the C.3 Technical Guidance Work Group and New Development Subcommittee. We appreciate the comments, suggestions, and guidance provided by the participating work group and subcommittee members listed below.

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The Clean Water Program recognizes the firms that helped prepare this document. BKF Engineers prepared the technical guidance for specific stormwater controls in Chapters 4 and 6, as well as Appendix C (Example Scenarios). Design, Community and Environment prepared Appendix B (Planting Guidance) and contributed to Section 5.7 (Selecting and Maintaining Plantings). Four Dimensions Landscape Company conducted peer review of Appendix B. Stopwaste.org staff reviewed the Bay-Friendly Landscaping and Integrated Pest Management sections of Appendix B. EOA, Inc., as the program management consultant, coordinated and compiled the information and assisted with the overall preparation of the document.

The Clean Water Program gratefully acknowledges the public agencies whose post-construction stormwater guidance documents served as inspiration and models for this document, including the Contra Costa Countywide Clean Water Program's C.3 Stormwater Guidebook, the Milpitas C.3 Stormwater Guidebook, the Santa Clara Valley Urban Runoff Pollution Prevention Program's C.3 Stormwater Handbook, the Santa Rosa Area SUSMP Guidelines, and Portland, Oregon's Stormwater Management Manual, and the San Mateo Water Pollution Prevention Program's C.3 Technical Guidance.

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Glossary of Terms

Alameda Countywide Clean Water Program	Now known as the Clean Water Program Alameda County.
Bay Area Hydrology Model (BAHM)	A computer software application to assist project applicants in sizing specialized detention facilities that will allow a project to meet the Flow Duration Control standard where required by the hydromodification management provision (Provision C.3.g) of the Municipal Regional Stormwater Permit. The BAHM is available for download at www.bayareahydrologymodel.com.
Beneficial Use	The uses of water of the state protected against degradation, such as domestic, municipal, agricultural and industrial supply; power generation; recreation; aesthetic enjoyment; navigation and preservation of fish and wildlife, and other aquatic resources or preserves.
Best Management Practice (BMP)	Any program, technology, process, siting criteria, operational method or measure, or engineered system, which when implemented prevents, controls, removes, or reduces pollution. Includes schedules of activities, prohibitions of practices, maintenance procedures, and other management practices to prevent or reduce water pollution. BMPs also include treatment requirements, operating procedures, and practices to control site runoff, spillage or leaks, litter or waste disposal, or drainage from raw material storage.
Bioinfiltration Area	A type of low development treatment measure designed to have a surface ponding area that allows for evapotranspiration, and to filter water through 18 inches of engineered biotreatment soil. After the water filters through the engineered soil, it encounters a 12-inch layer of rock in which an underdrain is typically installed. If the underlying soils have a saturated hydraulic conductivity rate of 1.6" per hour or greater, then the C.3.d amount of runoff is treated by evapotranspiration and infiltration. If the soils have a lower hydraulic conductivity rate, then the bioinfiltration area treats stormwater with evapotranspiration, some infiltration, and the remaining amount of the C.3.d amount of runoff is filtered and released into the underdrain. The difference between a bioinfiltration area and a bioretention area is that the bioinfiltration area is never lined with an impermeable layer; whereas, a bioretention area may be lined or unlined.

Bioretention Area	A type of low development treatment measure designed to have a surface ponding area that allows for evapotranspiration, and to filter water through 18 inches of engineered biotreatment soil. After the water filters through the engineered soil, it encounters a 12-inch layer of rock in which an underdrain is typically installed. If the underlying soils have a saturated hydraulic conductivity rate of 1.6" per hour or greater, then the C.3.d amount of runoff is treated by evapotranspiration and infiltration. If the soils have a lower hydraulic conductivity rate, or if infiltration is prohibited and the bioretention area is lined with an impermeable layer, then the bioretention area treats stormwater with evapotranspiration, some or no infiltration, and the remaining amount of the C.3.d amount of runoff is filtered and released into the underdrain. The difference between a bioinfiltration area and a bioretention area is that the bioinfiltration area is never lined with an impermeable layer; whereas, a bioretention area may be lined or unlined.
Biotreatment	A type of low impact development treatment allowed under Provision C.3.c of the MRP, if infiltration, evapotranspiration and rainwater harvesting and use are infeasible. As required by Provision C.3.c.i(2)(vi), biotreatment systems shall be designed to have a surface area no smaller than what is required to accommodate a 5 inches/hour stormwater runoff surface loading rate and shall use biotreatment soil as specified in the biotreatment soil specifications approved by the Regional Water Board, or equivalent.
Buffer Strip or Zone	Strip of erosion-resistant vegetation over which stormwater runoff is directed.
C.3	Provision of the Municipal Regional Stormwater NPDES Permit (MRP) that requires each Discharger to control the flow of stormwater and stormwater pollutants from new development and redevelopment sites over which it has jurisdiction.
C.3 Regulated Projects	Development projects as defined by Provision C.3.b.ii of the MRP. This includes public and private projects that create and/or replace 10,000 square feet or more of impervious surface, and restaurants, retail gasoline outlets, auto service facilities, and uncovered parking lots (stand-alone or part of another use) that create and/or replace 5,000 square feet or more of impervious surface. Single family homes that are not part of a larger plan of development are specifically excluded.

C.3.d Amount of Runoff	The amount of stormwater runoff from C.3 Regulated Projects that must receive stormwater treatment, as described by hydraulic sizing criteria in Provision C.3.d of the MRP.
California Association of Stormwater Quality Agencies (CASQA)	Publisher of the California Stormwater Best Management Practices Handbooks, available at www.cabmphandbooks.com. Successor to the Storm Water Quality Task Force (SWQTF).
Clean Water Act (CWA)	The Federal Water Pollution Prevention and Control Act, or Clean Water Act (33 U.S. Code 1251 *et seq.*) is intended to control or eliminate surface water pollution and establishes the National Pollutant Discharge Elimination System, which regulates surface water discharges from municipal storm drains, publicly-owned treatment works and industrial discharges.
Clean Water Program Alameda County	Formerly the Alameda Countywide Clean Water Program. The Clean Water Program is established by a memorandum of understanding among the 14 Alameda County cities, Alameda County (Unincorporated Area), the Alameda County Flood Control and Water Conservation District, and the Zone 7 Water Agency. All these agencies are listed as Co-permittees in a municipal stormwater NPDES permit adopted by the Regional Water Quality Control Board. The Clean Water Program implements common tasks and assists the member agencies to implement their local stormwater pollution prevention programs.
Complete Application	Applications that have been accepted by the Planning Department and have not received a letter within 30 calendar days stating that the application is incomplete (consistent with the Permit Streamlining Act). Where an application has not been accepted by the Planning Department and the applicant has received a letter within 30 days stating that the application is incomplete, the application will be deemed complete if the additional requested information is submitted to the satisfaction of the Planning Department.
Conditions of Approval (COAs)	Requirements the City may adopt for a project in connection with a discretionary action (e.g., adoption of an EIR or negative declaration or issuance of a use permit). COAs may include features to be incorporated into the final plans for the project and may also specify uses, activities, and operational measures that must be observed over the life of the project.
Conduit/Conveyance System/ Culvert	Channels or pipes for collecting and directing the flow of water. Conduits and conveyance systems may be open channels, covered channels or pipes. Culverts are covered channels or large diameter pipes.

Constructed Wetland	Constructed detention basins that have a permanent pool of water throughout the year and capacity for temporary additional storage of runoff that is released via an outlet structure. They differ from wet ponds in that they are typically shallower and have greater vegetation coverage.
Construction General Permit	A NPDES permit issued by the State Water Resources Control Board (SWRCB) for the discharge of stormwater associated with construction activity from soil disturbance of one (1) acre or more. The current Construction General Permit was adopted by the SWRCB on September 2, 2009, and went into effect July 1, 2010.
Design Storm	A hypothetical rainstorm defined by rainfall intensities and durations.
Detention	The temporary storage of stormwater runoff in ponds, vaults, within berms, or in depressed areas to allow treatment by sedimentation and metered discharge of runoff at reduced peak flow rates. See Infiltration and retention.
Directly-Connected Impervious Area (DCIA)	The area covered by a building, impermeable pavement, and/or other impervious surfaces, which drains directly into the storm drain without first flowing across permeable land area (e.g., turf buffers).
Directly Discharging	Outflow from a drainage conveyance system that is composed entirely or predominantly of flows from the subject property, development, subdivision, or industrial facility, and not commingled with flows from adjacent lands.
Direct Infiltration	Infiltration via methods or devices, such as dry wells or infiltration trenches, designed to bypass unsaturated surface soils and transmit runoff directly to groundwater.
Discharge	A release or flow of stormwater or other substance from a conveyance system or storage container.
Discharger	Any responsible party or site owner or operator within the MRP Permittees' jurisdiction whose site discharges stormwater runoff, or a non-stormwater discharge.
Drawdown Time	The time required for a stormwater detention or infiltration BMP to drain and return to the dry-weather condition. For detention BMPs, drawdown time is a function of basin volume and outlet orifice size. For infiltration BMPs, drawdown time is a function of basin volume and infiltration rate.
Dry Weather Flow	Flows that occur during periods without rainfall. In a natural setting, dry weather flows result from precipitation that infiltrates into the soil and slowly moves through the soil to the stream channel. Dry weather flows in storm drains may result from human activities, such as over-irrigation.

Dry Well	Structure placed in an excavation or boring, or excavation filled with open-graded rock, that is designed to collect stormwater and infiltrate into the subsurface soil.
Erosion	The diminishing or wearing away of land due to wind or water. Often the eroded debris (silt or sediment) becomes a pollutant via stormwater runoff. Erosion occurs naturally, but can be intensified by land disturbing and grading activities such as farming, development, road building, or timber harvesting.
Evapotranspiration	Evaporating water into the air directly or through plant transpiration.
Extended Detention Basin	Constructed basins with drainage outlets that are designed to detain runoff from a water quality design storm for some minimum time (e.g., 48 hours) to allow settling of sediment and pollutants.
Filter Fabric	Geotextile of relatively small mesh or pore size that is used to: (a) allow water to pass through while keeping sediment out (permeable); or (b) prevent both runoff and sediment from passing through (impermeable).
Flow-based Treatment Measures	Stormwater treatment measures that treat pollutants from a moving stream of water through filtration, infiltration, and/or biological processes.
Flow Duration	Either a) the total hours that surface flow from a watershed or drainage area occurs at a specified magnitude in response to a long-term time history of rainfall inputs, or b) the cumulative percentage of total hours that flows exceed the specified magnitude (as used in the BAHM). The overall distribution of flow durations is then expressed by a histogram or cumulative distribution curve, showing flow durations for equal subdivisions of the full range of flow magnitudes occurring over time.
Flow Duration Control	An approach to mitigating development-caused hydromodification which involves developing continuous simulation models of runoff from both pre-project and post-project site conditions, comparing flow durations for a designated range of flows, and designing specialized detention and discharge structures to reduce excess post-project flow duration for flows in the designated range (See Chapter 7).
Flow-Through Planter Box	Structure designed to treat stormwater by intercepting rainfall and slowly draining it through filter media and out of planter.
Grading	The cutting and/or filling of the land surface to a desired shape or elevation.
Green Roof/ Roof Garden	Vegetated roof systems that retain and filter stormwater prior to drainage off building rooftops.

Groundwater	Subsurface water that occurs in soils, and geologic formations that are fully saturated.
Hazardous Waste	By-products of human activities that can pose a substantial or potential hazard to human health or the environment when improperly managed. Possesses at least one of four characteristics (flammable, corrosivity, reactivity, or toxicity), or appears on special EPA lists.
Head	In hydraulics, energy represented as a difference in elevation. In slow-flowing open systems, the difference in water surface elevation, e.g., between an inlet and outlet.
Heritage Tree	An individual tree of any size or species given the 'heritage tree' designation as defined by the municipality's tree ordinance or other section of the municipal code.
High-Flow Bypass	In stormwater treatment measures, a pipe, outlet, or other structure designed to convey flood flows directly to the storm drain systems without entering the treatment measure.
Hydrodynamic Separator	A commonly used term for mechanical stormwater treatment systems that are designed as flow-through structures with a settling or separation unit to remove sediment and other pollutants that may settle to the bottom of the separation unit.
Hydrograph	Runoff flow rate plotted as a function of time.
Hydromodification	The modification of a stream's hydrograph, caused in general by increases in flows and durations that result when land is developed (e.g., made more impervious). The effects of hydromodification include, but are not limited to, increased bed and bank erosion, loss of habitat, increased sediment transport and deposition, and increased flooding.
Hydrologic Soil Group	Classification of soils by the Natural Resources Conservation Service (NCRS) into A, B, C, and D groups according to infiltration capacity.
Imperviousness	A term applied to surfaces – roads, sidewalks, rooftops, and parking lots – that prevent or inhibit rainfall from sinking into groundcover and groundwater.
Impervious surface	A surface covering or pavement of a developed parcel of land that prevents the land's natural ability to absorb and infiltrate rainfall/stormwater. Impervious surfaces include, but are not limited to, roof tops; walkways; patios; driveways; parking lots; storage areas; impervious concrete and asphalt; and any other continuous watertight pavement or covering. Landscaped soil and pervious pavement, including pavers with pervious openings and seams, underlain with pervious soil or pervious storage material, such as a gravel layer sufficient to hold at least the

Impervious surface (continued)	Provision C.3.d volume of rainfall runoff are not impervious surfaces. Open, uncovered retention/detention facilities are not considered impervious surfaces for purposes of determining whether a project is a Regulated Project under Provisions C.3.b and C.3.g. Open, uncovered retention/detention facilities shall be considered impervious surfaces for purposes of runoff modeling and meeting the Hydromodification standard.
Indirect Infiltration	Infiltration via facilities, such as swales and bioretention areas, that are expressly designed to hold runoff and allow it to percolate into surface soils. Runoff may reach groundwater indirectly or may be underdrained through subsurface pipes.
Infiltration	Seepage of runoff through the soil to mix with groundwater. See retention.
Infiltration Devices	Infiltration facilities that are deeper that they are wide and designed to infiltrate stormwater runoff into the subsurface and, as designed, bypass the natural groundwater protection afforded by surface soil. These devices include dry wells, injection wells and infiltration trenches (includes French drains).
Infiltration Facilities	A term that refers to both infiltration devices and measures.
Infiltration Measures	Infiltration facilities that are wider than they are deep (e.g., bioinfiltration, infiltration basins and shallow wide infiltration trenches and dry wells).
Infiltration Trench	Long narrow trench filled with permeable material (e.g., gravel), designed to store runoff and infiltrate through the bottom and sides into the subsurface soil.
Inlet	An entrance into a ditch, storm sewer, or other waterway.
Integrated Management Practice (IMP)	A stormwater treatment measure that meets both stormwater treatment and hydromodification management objectives.
Integrated Pest Management (IPM)	An approach to pest control that utilizes regular monitoring to determine if and when treatments are needed and employs physical, mechanical, cultural, biological, and educational tactics to keep pest numbers low enough to prevent unacceptable damage or annoyance.
Low Impact Development	A land planning and engineering design approach with a goal of reducing stormwater runoff and mimicking a site's predevelopment hydrology by minimizing disturbed areas and impervious cover and then infiltrating, storing, detaining, evapotranspiring, and/or biotreating stormwater runoff close to its source, or onsite.

Low Impact Development (LID) Treatment	Removal of pollutants from stormwater runoff using the following types of stormwater treatment measures: rainwater harvesting and use, infiltration, evapotranspiration, or, where these are infeasible, biotreatment.
Maintenance Plan	A plan detailing operation and maintenance requirements for stormwater treatment measures and/or structural hydromodification measures incorporated into a project.
Maximum Extent Practicable (MEP)	A standard for implementation of stormwater management actions to reduce pollutants in stormwater. Clean Water Act (CWA) 402(p)(3)(B)(iii) requires that municipal stormwater permits "shall require controls to reduce the discharge of pollutants to the maximum extent practicable, including management practices, control techniques and system, design and engineering methods, and such other provisions as the Administrator or the State determines appropriate for the control of such pollutants." Also see State Board Order WQ 2000-11.
Media Filter	Two-chambered system that includes a pretreatment settling basin and a filter bed filled with sand or other absorptive filtering media.
Municipal Regional Stormwater Permit (MRP)	The Phase I municipal stormwater NPDES permit under which discharges are permitted from municipal separate storm sewer systems throughout Alameda County and other NPDES Phase I jurisdictions within the San Francisco Bay Regionl
New Development	Land disturbing activities; structural development, including construction or installation of a building or structure, creation of impervious surfaces; and/or land subdivision.
Non-Stormwater Discharge	Any discharge to municipal separate storm drain that is not composed entirely of stormwater. Some types of non-stormwater discharges may be authorized by NPDES permits and others prohibited.
NPDES Permit **NPDES Permit (continued)**	An authorization, license, or equivalent control document issued by EPA or an approved State agency to implement the requirements of the National Pollutant Discharge Elimination System (NPDES) program. As part of the 1972 Clean Water Act, Congress established the NPDES permitting system to regulate the discharge of pollutants from municipal sewers and industries. The NPDES program was expanded in 1987 to incorporate permits for stormwater discharges as well. Regional Water Quality Control Boards issue stormwater NPDES Permits to local government agencies placing provisions on allowable discharges of municipal stormwater to waters of the state.
Numeric Criteria	Sizing requirements for stormwater treatment controls established in Provision C.3.d. of the MRP.

Operation and Maintenance (O&M)	Refers to requirements in the storm water NPDES permit to inspect treatment BMPs and implement preventative and corrective maintenance in perpetuity. See Chapter 8.
Operational Source Control Measure	Low technology, low cost activities, procedures, or management practices designed to prevent pollutants associated with site functions and activities from being discharged with stormwater runoff. Examples include good housekeeping practices, employee training, standard operating practices, inventory control measures, etc.
Outfall/ Outlet	The point where stormwater discharges from a pipe, channel, ditch, or other conveyance to a waterway.
Percentile Rainfall Intensity	A method of designing flow-based treatment controls that ranks long-term hourly rainfall intensities and selects the 85th percentile value, and then doubles this value.
Permeability	A property of soil that enables water or air to move through it. Usually expressed in inches/hour or inches/day.
Pervious Surface	Permeable hardscape or paved surface that allows surface runoff to infiltrate into surface soil (e.g., turf block, brick, natural stone, cobbles, gravel).
Perviousness	The permeability of a surface that can be penetrated by stormwater to infiltrate the underlying soils.
Point of Compliance	For design to meet Flow Duration Control requirements for hydromodification management, the point at which pre-project runoff is compared to post-project runoff, usually near the point where runoff leaves the project area.
Pollutant	A substance introduced into the environment that adversely affects or potentially affects the usefulness of a resource.
Post-Construction Stormwater Control	See Stormwater Control.
Potential Rainwater Capture Area	The impervious area from which rainwater may be potentially be captured, if rainwater harvesting and use were implemented for a project. If the entire site is evaluated for rainwater harvesting and use feasibility, this consists of the impervious area of the proposed project; for redevelopment projects that replace 50% or more of the existing impervious surface, it also includes the areas of existing impervious surface that are not modified by the project. If only a roof area is evaluated for rainwater harvesting and use feasibility, the potential rainwater capture area consists only of the applicable roof area.

Precipitation	Any form of rain or snow.
Provision C.3	A reference to the requirements in the MRP requiring each MRP Discharger to control the flow of stormwater and stormwater pollutants from new and redevelopment sites over which it has jurisdiction.
Rational Method	A method of calculating runoff flows based on rainfall intensity and the amount of runoff from the tributary area.
Redevelopment	Land-disturbing activity that results in the creation, addition, or replacement of exterior impervious surface area on a site on which some past development has occurred. The MRP excludes interior remodels and routine maintenance or repair, including roof or exterior surface replacement, pavement resurfacing, repaving and road pavement structural section rehabilitation within the existing footprint.
Regional Water Quality Control Board, San Francisco Bay Area Water Board (RWQCB)	One of nine California Regional Water Boards, the Regional Water Board for the San Francisco Bay Region is responsible for implementing pollution control provisions of the Clean Water Act and California Water Code within the area that drains to San Francisco Bay. Also referred to as Water Board.
Retention	The storage of stormwater to prevent it from leaving the development site; may be temporary or permanent.
Runoff	Water originating from rainfall and other sources (e.g., sprinkler irrigation) that is found in drainage facilities, creeks, streams, springs, seeps, ponds, lakes, wetlands, and shallow groundwater.
Screening Density	A threshold of density (e.g., number of units or interior floor area) per acre of impervious surface, associated with a certain potential demand for non-potable water, for C.3 regulated projects. Screening densities are used to determine the feasibility and infeasibility of rainwater harvesting and use. Screening density varies according to location (see Attachment 2 of the LID feasibility forms in Appendix J.) If the screening density is met or exceeded, the Rainwater Harvesting and Use Feasibility Worksheet must be completed for the project.
Sedimentation	The process of depositing soil particles, clays, sands, or other sediments that were picked up by runoff.
Sediments	Soil, sand and minerals washed from land into water, usually after rain.

Self-Retaining Area	A portion of a development site designed to retain the first one inch of rainfall (by ponding and infiltration and/or evapotranspiration) without producing stormwater runoff. Self-retaining areas must have at least a 2 :1 ratio of contributing area to a self-retaining area and a 3" ponding depth. Self-retaining areas may include graded depressions with landscaping or pervious pavement. Areas that Contribute Runoff to Self-Retaining Areas are impervious or partially pervious areas that drain to self-retaining areas.
Self-Treating Area	A portion of a development site in which infiltration, evapotranspiration and other natural processes remove pollutants from stormwater. Self-treating areas may include conserved natural open areas, areas of landscaping, green roofs and pervious pavement. Self-treating areas treat only the rain falling on them and do not receive stormwater runoff from other areas.
Site Design Measures	Site planning techniques to conserve natural spaces and/or limit the amount of impervious surface at new development and significant redevelopment projects in order to minimize runoff and the transport of pollutants in runoff.
Source Control Measures	Land use or site planning practices, or structural or non structural measures, that aim to prevent runoff pollution by reducing the potential for contact with rainfall runoff at the source of pollution. Source control measures minimize the contact between pollutants and urban runoff.
Special Projects	Certain types of smart growth, high density and transit oriented development projects that are allowed, under Provision C.3.e.ii of the MRP, to receive LID treatment reductions. The specific development project types will be described in an amendment to the MRP, anticipated in Fall 2011.
Storm Drains	Above and belowground structures for transporting stormwater to creeks or outfalls for flood control purposes.
Storm Event	A rainfall event that produces more than 0.1 inch of precipitation and is separated from the previous storm event by at least 72 hours of dry weather.
Stormwater	Stormwater runoff, snow-melt runoff, surface runoff, and drainage, excluding infiltration and irrigation tailwater.
Stormwater Control	A design feature of a development or redevelopment project, or a routinely-conducted activity that is intended to prevent, minimize or treat pollutants in stormwater, or to reduce erosive flows during the life of the project. Storm water control is a term that collectively refers to site designs to promote water quality, source control

Stormwater Control (continued)	measures, stormwater treatment measures, and hydromodification management measures. Also referred to as "post-construction stormwater control" or "post-construction stormwater measure."
Stormwater Pollution Prevention Plan (SWPPP)	A plan providing for temporary measure to control sediment and other pollutants during construction.
Stormwater Treatment Measure	Any engineered system designed to remove pollutants from stormwater runoff by settling, filtration, biological degradation, plant uptake, media absorption/adsorption or other physical, biological, or chemical process. This includes landscape-based systems such as vegetated swales and bioretention units as well as proprietary systems. Sometimes called a treatment control, treatment control measure treatment system, or treatment control BMP.
Total Project Cost	Total project cost includes the construction (labor) and materials cost of the physical improvements proposed; however, it does not include land, transactions, financing, permitting, demolition, or off-site mitigation costs.
Treatment	Any method, technique, or process designed to remove pollutants and/or solids from polluted stormwater runoff, wastewater, or effluent.
Vector Control	Any method to limit or eradicate vectors of vector born diseases, for which the pathogen (e.g. virus or parasite) is transmitted by a vector which can be mammals, birds or arthropods, especially insects, and more specifically mosquitoes. For the purposes of this document, vector control refers to mosquito control.
Vegetated Buffer Strip	Linear strips of vegetated surfaces that are designed to treat sheet runoff flow from adjacent surfaces.
Volume-Based Stormwater Treatment Measures	Stormwater treatment measures that detain stormwater for a certain period and treat primarily through settling and infiltration.
Water Quality Inlet	Systems that contain one or more chambers that promote sedimentation of coarse materials and separation of undissolved oil and grease from stormwater. Also referred to as oil/water separators.
Water Quality Volume (WQV)	For stormwater treatment measures that depend on detention to work, the volume of water that must be detained to achieve maximum extent practicable pollutant removal. This volume of water must be detained for a specified drawdown time.
WEF Method	A method for determining the required volume of treatment BMPs, recommended by the Water Environment Federation and American Society of Civil Engineers. Described in Urban Runoff Quality Management (WEF/ASCE, 1998).

Chapter

1

Introduction / How to Use this Handbook

This Chapter describes the purpose of this handbook and gives an overview of its contents.

1.1 Purpose of this Handbook

This Alameda Countywide Clean Water Program (Clean Water Program) handbook is meant to help developers, builders, and project sponsors include post-construction stormwater controls in their projects, in order to meet local municipal requirements and State requirements in the Municipal Regional Stormwater Permit (MRP). The municipalities have to require post-construction stormwater controls as part of their obligations under Provision C.3 of the MRP. This is a National Pollutant Discharge Elimination System (NPDES) permit issued by the San Francisco Bay Regional Water Quality Control Board (Water Board), allowing municipal stormwater systems to discharge to local creeks, San Francisco Bay, and other water bodies. In case of conflicting information between this handbook and the MRP, the MRP shall prevail.

The term "***post-construction stormwater control***" refers to permanent features included in a project to reduce pollutants in stormwater and/or erosive flows during the life of the project – after construction is complete d. The term "post-construction stormwater control" encompasses low-impact development (LID), which reduces water quality impacts by preserving and re-creating natural landscape features, minimizing imperviousness, and using stormwater as a resource, rather than a waste product.

> ***"Post-construction stormwater controls"*** are permanent features included in a project to reduce pollutants in stormwater "and/or erosive flows after construction is completed.

Information on best management practices (BMPs) that protect stormwater during construction, is available at www.cleanwaterprogram.org (click on "Businesses," then "Construction Related Issues").

Post-construction stormwater controls are required for both private and public projects. Although this handbook is written primarily for sponsors of private development projects, its technical guidance also applies to publicly-sponsored projects. Municipalities may also find the handbook useful for training municipal staff and consulting plan checkers.

1.2 What is the Clean Water Program?

The Clean Water Program is an association of the agencies in Alameda County that manage separate storm drain systems and creek channels that discharge urban runoff to San Francisco Bay. The Clean Water Program has 17 member agencies: the 14 cities in the County, Unincorporated Alameda County, Zone 7 Water Agency, and the Alameda County Water Conservation and Flood Control Division.

The Clean Water Program's member agencies, and other agencies throughout the region, are joint permit holders of the MRP. Each member agency is individually responsible for implementing the MRP requirements, but participating in the Program helps them collaborate on Clean Water Program initiatives that benefit all members. More information on the Program is available on its website, www.cleanwaterprogram.org.

1.3 How to Use this Handbook

> Some requirements in this Clean Water Program guidance document ***may vary*** from one local jurisdiction

When using this Clean Water Program guidance document, please keep in mind that ***some requirements may vary from one local jurisdiction to the next.*** In the very early stages of project planning, contact the municipal planning staff to schedule a pre-application meeting to learn how the C.3 requirements – and other planning, zoning and building requirements – will apply to your project. Also, because regulatory requirements may change, be sure to ask the local municipal staff to provide any updates of information or requirements.

It's important to note that post-construction stormwater design requirements are complex and technical: most projects will require the assistance of a qualified civil engineer, architect, landscape architect, and/or geotechnical engineer.

To help you get started, a synopsis of the handbook's chapters and appendices is provided below:

- Chapter 2 explains how development affects stormwater quality, how post-construction stormwater measures/LID help reduce these impacts, and gives a detailed explanation of ***Provision C.3 requirements***.
- Chapter 3 gives an overview of how the post-construction stormwater requirements fit into a typical development review process, and offers ***step-by-***

step instructions on how to incorporate stormwater control/LID designs into planning permit and building permit application submittals for your project.

- Chapter 4 presents information on ***site design measures***, including guidance for self-treating and self-retaining areas, which can help reduce the size of stormwater treatment measures.
- Chapter 5 provides ***general technical guidance for stormwater treatment measures***, including hydraulic sizing criteria, the applicability of non-LID treatment measures, manufactured treatment measures, using "treatment trains," infiltration guidelines, plant selection and maintenance, mosquito control, and integrating stormwater treatment with hydromodification management.
- Chapter 6 gives technical guidance for ***specific types of stormwater treatment measures***, including bioretention areas, flow-through planters, vegetated swales, vegetated buffer strips, tree well filters, infiltration trenches, extended detention basins, pervious paving, green roofs, and media filters.
- Chapter 7 explains the requirements for ***hydromodification management measures***, which keep the flow rates and volumes of certain post-construction stormwater flows at pre-construction levels, in order to minimize development-induced erosion in creek channels.
- Chapter 8 explains the ***operation and maintenance*** requirements for stormwater treatment measures.
- Chapter 9 describes the MRP's Provision, which allows projects to contribute to off-site ***alternative compliance*** projects instead of constructing on-site stormwater treatment measures.
- Appendix A is provided for each agency to include its own ***local requirements***, such as the agency's conditions of approval, Source Control Measures List, and Impervious Surface Form.
- Appendix B includes a ***list of plants*** appropriate for use in LID treatment measures. It also offers general guidance on plant selection and maintenance.
- Appendix C presents ***example scenarios***, showing how site design, source controls and treatment measures can be incorporated into projects.
- Appendix D consists of the ***Mean Annual Precipitation Map*** for Alameda County.
- Appendix E describes manufactured stormwater treatment measures that have ***limited applicability***, including inlet filters, oil/water separators, hydrodynamic separators, and media filters.
- Appendix F presents guidelines for using stormwater controls that promote on-site ***infiltration*** of stormwater.
- Appendix G provides guidance for ***controlling mosquito production*** in stormwater treatment measures.

- Appendix H includes templates for preparing stormwater treatment measure ***maintenance plans***.
- Appendix I is the ***Hydromodification Management Susceptibility Map***.
- Appendix J includes guidance for using the ***Feasibility/Infeasibility Criteria*** to determine when the full C.3.d amount of stormwater runoff cannot be treated with rainwater harvesting and use, infiltration or evapotranspiration, in which case stormwater treatment requirements can be met with biotreatment..
- Appendix K provides guidance on using the ***Special Projects Criteria*** approved by the Regional Water Board to identify infill, high density, and transit oriented development projects that may receive LID treatment reduction credits.
- Appendix L includes regional ***Soil Specifications*** approved by the Regional Water Board for use in stormwater biotreatment measures.
- Appendix M will feature ***BMP Specifications for Small Projects***, after these specifications become available in latter half of 2012.

1.4 Precedence

In case of conflicting information between this handbook and the Municipal Regional Stormwater Permit (MRP), the MRP shall prevail.

Chapter

2

Background / Regulatory Requirements

This Chapter summarizes stormwater problems resulting from development and explains the post-construction requirements for development projects.

2.1 Stormwater Problems in Developed Areas

Throughout the country, stormwater runoff is a leading source of pollutants for water bodies that fail to meet water quality standards[1]. In the San Francisco Bay watershed, urban and agricultural runoff is generally considered to be the ***largest source of pollutants*** to aquatic systems.[2] Although stormwater runoff is part of the natural hydrologic cycle, human activities can alter the natural drainage patterns, introduce pollutants, and increase erosion, degrading the natural habitats.

2.1.1 Stormwater Runoff in a Natural Setting

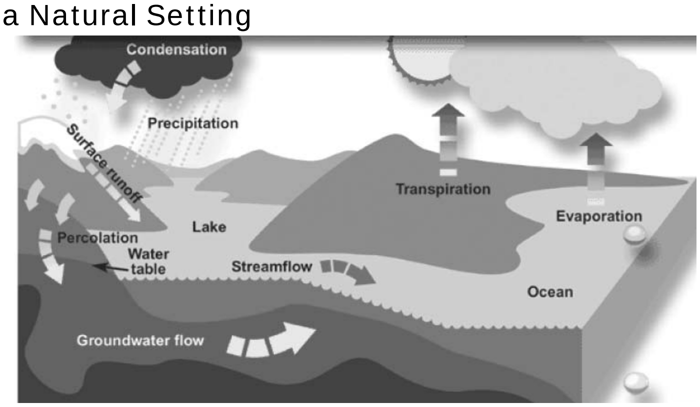

Figure 2-1: The Water Cycle (NGRDC/GDNR, 2005/06)

The natural water cycle circulates the earth's water from sky, to land, to sea, to sky in a never-ending cycle. In a pristine setting, soil is covered with a complex matrix of mulch, roots and pores that absorb rainwater. As ***rainwater infiltrates slowly into the soil***, natural biologic processes remove impurities. Because most rainstorms are not large enough to fully saturate the soil, only a small

[1] See the USEPA's list of Stormwater Frequently Asked Questions, at http://cfpub.epa.gov/npdes/faqs.cfm?program_id=6

[2] San Francisco Bay Regional Water Quality Control Board, Basin Plan, 2004

percentage of annual rainwater flows over the surface as runoff. The natural vegetation tends to slow the runoff in a meandering fashion, allowing suspended particles and sediments to settle. In the natural condition, the hydrologic cycle creates a stable supply of groundwater, and surface waters are naturally cleansed of impurities. Sediment is carried with the flow of stormwater runoff, but in a natural setting, creeks typically find an equilibrium in which they manage normal sediment flows with no impairment of their vital functions.

2.1.2 Stormwater Runoff in Urban or Urbanizing Areas

In developed areas, impervious surfaces – such as roads, parking lots and rooftops – prevent water from infiltrating into the soil. ***Most of the rainfall remains on the surface***, where it washes debris, dirt, vehicle fluids, chemicals, and other pollutants into the local storm drain systems. Once in the storm drain, polluted runoff flows directly into creeks and other natural bodies of water. Figure 2-2 contrasts the percentage of rainfall that becomes stormwater runoff in a natural and an urban setting.

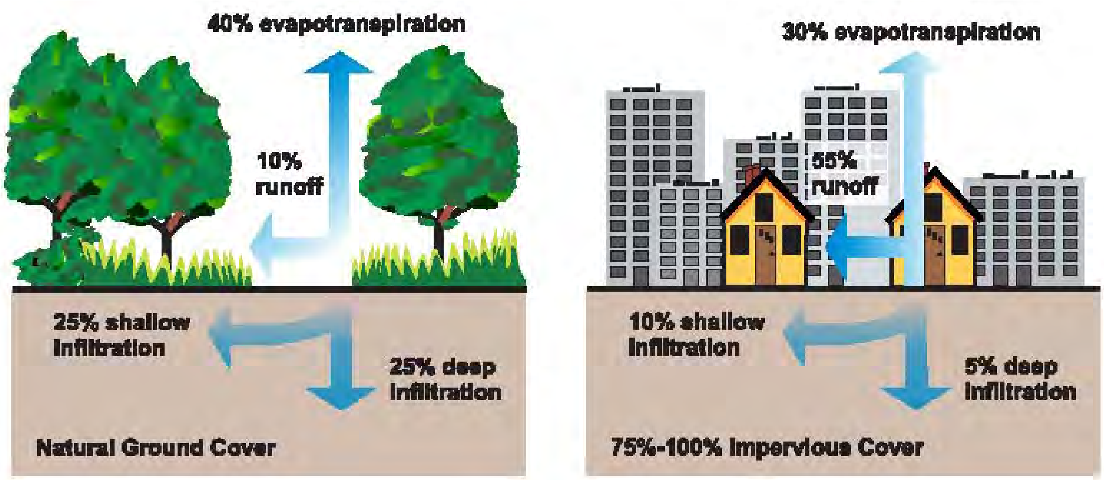

Figure 2-2: Change in volume of stormwater runoff after development. (USEPA, 2003)

Not only does urban stormwater runoff ***wash pollutants into local waterways***, but it can also cause natural creek channels to erode. When impervious surfaces are built, rainwater runs off at ***faster rates and in larger volumes*** than in the natural condition. Natural creek channels must suddenly handle much greater volumes of water traveling at much faster rates, greatly increasing the duration of erosive forces on their bed and banks. In response to these changes, creek channels enlarge by eroding and may also become less stable. This effect is called hydrograph modification or hydromodification. Figures 2-3 and 2-4 contrast creek channels in the natural condition and creek channels subject to hydromodification.

2.2 Post-Construction Stormwater Controls

Various permanent control measures have been developed in order to ***reduce the long-term impacts*** of development on stormwater quality and creek channels. These permanent control measures are often called post-construction stormwater controls/low impact development (LID), or post construction best management practices (BMPs) to distinguish them from the temporary construction BMPs that are used to control sedimentation and erosion while a project is being constructed. LID reduces water quality impacts by preserving and re-creating natural landscape features, minimizing imperviousness, and then infiltrating, storing, detaining, evapotranspiring (evaporating stormwater into the air directly or through plant transpiration), and/or biotreating stormwater runoff close to its source, or onsite.

Figure 2-3: Creek with Natural Banks

Figure 2-4: Creek Subject to Hydromodification

Post-construction stormwater control measures can be divided into four categories: site design measures, source control measures, stormwater treatment measures, and hydromodification management measures. Each of these categories is described below.

2.2.1 Site Design Measures

Site design measures are ***site planning technique***s that help reduce stormwater pollutants and increases in the peak runoff flow and duration, by protecting existing natural resources and reducing impervious surfaces of development projects. Some examples of site design measures include:

- Minimize land disturbance and preserve high-quality open space;
- Minimize impervious surfaces by using narrow streets, driveways and sidewalks;
- Minimize impervious surfaces that are directly connected to the storm drain system (unless the connection includes a stormwater treatment measure). One example of "disconnecting" impervious surfaces is to direct roof downspouts to splash blocks or "bubble-ups" in landscaped areas;
- Cluster structures and paved surfaces; and
- Use landscaping as a drainage feature.

2.2.2 Source Control Measures

Source control measures consist of either structural project features or operational "good housekeeping" practices that ***prevent pollutant discharge and runoff*** at the source, and keeping pollutants from coming into contact with stormwater. Examples of structural source controls include:

- Roofed trash enclosures,
- Berms that control runon to or runoff from a potential pollutant source, and
- Indoor mat/equipment washracks that are connected to the sanitary sewer. (Note that any sanitary sewer connections must be approved by the local permitting authority.)

Examples of operational source controls include:

- Street sweeping and
- Regular inspection and cleaning of storm drain inlets.

2.2.3 Stormwater Treatment Measures

Stormwater treatment measures are engineered systems that are designed to ***remove pollutants from stormwater*** using natural processes such as filtration, infiltration, flotation and sedimentation. Stormwater treatment measures must be sized to comply with one of the hydraulic design criteria listed in the municipal stormwater permit's Provision C.3.d, which are described in Section 5.1 of this guidance document. Chapter 6 provides technical guidance specific to the following treatment measures:

- Bioretention areas,
- Flow-through planter boxes,
- Tree well filters (effective December 1, 2011, high flow rate tree well filters are allowed only in Special Projects - see Appendix K),
- Vegetated buffer strips,
- Infiltration trenches,
- Extended detention basins,
- Pervious paving,
- Turf block and permeable joint pavers,
- Green roofs,
- Rainwater harvesting and use, and
- Media filters (effective December 1, 2011, media filters are allowed only in Special Projects - see Appendix K).

Effective ***December 1, 2011***, the Municipal Regional Stormwater Permit (MRP) requires stormwater treatment requirements to be met by using evapotranspiration, infiltration, rainwater harvesting and reuse. Where this is not feasible, biotreatment is allowed. Appendix J provides guidance for making this feasibility determination. Media filters and high flow rate tree well filters are allowed only in Special Projects. See Section 2.3.2 for more information on stormwater treatment requirements, and Appendix K for more information on Special Projects.

2.2.4 Hydromodification Management Measures

Hydromodification management (HM) measures include site design and source control measures that promote infiltration or otherwise ***minimize the change in the rate and flow of runoff***, when compared to the pre-development condition. HM measures also include constructed facilities (such as basins, ponds, or vaults) that manage the flow rates of stormwater leaving a site, and under some conditions can also include re-engineering of at-risk channels downstream from the site. In some cases a single stormwater treatment measure may be used to meet both the treatment and HM objectives for a project. A dual-use measure of this type is sometimes called an "integrated management practice," or IMP.

2.3 Municipal Stormwater Permit Requirements

The development or redevelopment of property represents an opportunity to incorporate post-construction controls that can reduce water quality impacts over the life of the project. Since the first countywide municipal stormwater permit was adopted in 1991, the Clean Water Program municipal agencies have required new development and redevelopment projects to incorporate post-construction stormwater site design, source control, and treatment measures in their projects to the maximum extent practicable (MEP). To meet the MEP standard, municipalities must employ stormwater control measures that are technically feasible (that is, are likely to be effective) and are not cost prohibitive.

The Municipal Regional Stormwater Permit (MRP), adopted by the Water Board in October 2009, includes more prescriptive requirements for incorporating post-construction stormwater control/LID measures into new development and redevelopment projects than those included in the last countywide permit's update in 2003. These requirements are known as Provision C.3, and the text of Provision C.3 and the entire MRP can be found at http://www.waterboards.ca.gov/sanfranciscobay/board_decisions/adopted_orders/2009/R2-2009-0074.pdf.

2.3.1 Do the C.3 Requirements Affect My Project?

Provision C.3.c establishes thresholds at which new development and redevelopment projects must comply with Provision C.3, although it also states that "all projects regardless of size should consider incorporating appropriate source control and site design measures that minimize stormwater pollutant discharges to the maximum extent practicable [MEP]…". Regardless of a project's need to comply with Provision C.3, municipalities apply the MEP standard, including standard ***stormwater conditions of approval*** for projects that receive development permits. These conditions of approval require appropriate site design, source control measures, and, in some cases, treatment measures.

> Regardless of a project's need to comply with Provision C.3, municipalities apply standard ***stormwater conditions of approval*** to projects that receive development permits.

PROVISION C.3 THRESHOLDS

The thresholds for determining whether Provision C.3 applies to a project are based on the amount of impervious surface that is created and/or replaced by a project, as described below.

- Since August 15, 2006, private or public projects that create and/or replace ***10,000 square feet or more*** of impervious surface must comply with Provision C.3.
- Effective ***December 1, 2011***, the threshold for requiring stormwater treatment is reduced from 10,000 to ***5,000 square feet, or more,*** of impervious surface for the following project categories: uncovered parking areas (stand-alone or part of another use), restaurants, auto service facilities[1] and retail gasoline outlets.

"DEEMED COMPLETE" EXCLUSIONS

- Development applications "deemed complete" for review by the planning department before December 1, 2009 and "diligently pursued[2]" by the project applicant will not be affected by the requirements that are effective December 1, 2011.
- Development applications that were "deemed complete" for review, by the planning department, after December 1, 2009, but receive final discretionary approval before ***December 1, 2011*** are not affected by the requirements that are effective December 1, 2011.

CALCULATING IMPERVIOUS SURFACE

An "impervious surface" is any material that prevents or substantially ***reduces infiltration of water into the soil.*** This includes building roofs, driveways, patios, parking lots, impervious decking, streets, sidewalks, and any other continuous watertight pavement or covering. Impervious surface is calculated in terms of square feet or, for larger sites, in acres. When calculating the area of building roofs, be sure to include not only the footprint of the main building or structure, but also any garages, carports, sheds, or other miscellaneous structures. Landscaped soil and pervious pavement, as long as areas of pervious pavement are underlain with pervious soil or pervious storage material, such as a gravel layer sufficient to hold at least the Provision C.3.d volume of rainfall runoff are not impervious surfaces. Open, uncovered retention/detention facilities are not considered impervious surfaces for purposes of determining whether a project is a Regulated Project under Provisions C.3.b and C.3.g. Open, uncovered retention/detention facilities shall be considered impervious surfaces for purposes of runoff modeling and meeting the Hydromodification standard. The municipalities use an "Impervious Surface Form" to help project applicants with these calculations. ***Contact your local jurisdiction*** to obtain its impervious surface form.

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[1] Auto service facilities include the specific Standard Industrial Classification Codes, as follows:
5013: Wholesale distribution of motor vehicle supplies, accessories, tools, equipment, and parts.
5014: Wholesale distribution of tires and tubes for passenger and commercial vehicles.
7532: Repair of automotive tops, bodies, and interiors, or automotive painting and refinishing.
7533: Installation, repair, or sale and installation of automotive exhaust systems.
7534: Repairing and retreading automotive tires.
7536: Installation, repair, or sales and installation of automotive glass.
7537: Installation, repair, or sales and installation of automotive transmissions.

[2] Diligent pursuance may be demonstrated by the project applicant's submittal of supplemental information to the original application, plans, or other documents required for any necessary approvals of the project.

EXCLUSIONS FROM PROVISION C.3

Provision C.3.c of the municipal stormwater permit excludes specific types of projects from Provision C.3 requirements, even if they meet the threshold requirements described above. The list of excluded project types is shown in Table 2-1, below.

Table 2-1
Projects Excluded from Provision C.3 Numerically Sized Treatment Requirements

	Excluded Projects
Commercial, industrial, residential, or other development	Detached single-family home projects that are not part of a larger plan of development[4].
Road projects	▪ Roadway reconstruction that does not add one or more new lanes of travel or new roadway; ▪ Widening of roadways that does not add one or more new lanes of travel; ▪ Impervious trails with a width of 10 feet or less and located more than 50 feet from top of creek banks. ▪ Sidewalk projects in the public right of way that are not built as part of new streets or roads; ▪ Bicycle lane projects in the public right of way that are not built as part of new streets or roads.[5] ▪ Sidewalks built as part of new streets or roads that are constructed to drain to adjacent vegetated areas; ▪ Bicycle lanes built as part of new streets or roads that are not hydraulically connected to the new streets or roads, and that are constructed to direct stormwater runoff to adjacent vegetated areas; ▪ Impervious trails built to direct stormwater runoff to adjacent vegetated areas or other non-erodible pervious areas, preferably away from creeks or toward the outboard side of levees; ▪ Sidewalks, bicycle lanes or trails built with permeable surfaces; ▪ Caltrans highway projects and associated facilities.
Redevelopment projects (including pavement resurfacing)	Interior remodels and routine maintenance or repair, such as roof or exterior wall surface replacement; or pavement resurfacing within the existing footprint.
Source: San Francisco Bay Regional Water Quality Control Board, October 2009	

[4] Effective December 1, 2012, detached single-family home projects that are not part of a larger plan of development and that create and/or replace 2,500 square feet or more of impervious surface are required to implement site design measures specified in Provision C.3.i.

[5] If an existing road is widened to add a traffic lane in addition to a new bicycle lane, and the bike lane is not hydraulically separated from the road, treatment of runoff from the bike lane would be required.

2.3.2 What is Required by Provision C.3?

Except for the excluded projects listed in Table 2-1, projects that create and/or replace ***10,000 square feet or more*** of impervious surface must incorporate the stormwater controls listed below. Effective ***December 1, 2011,*** projects that consist of restaurants, auto service facilities, retail gasoline outlets, and surface parking areas (stand-alone or part of another use) that create and/or replace 5,000 square feet or more of impervious surface must also implement the stormwater controls listed below.

- Site design measures,
- Source control measures, and
- Low impact development (LID) treatment measures that are hydraulically sized as specified by the MRP. LID treatment is ***evapotranspiration, infiltration, and/or rainwater harvesting and reuse***, unless this is infeasible (Appendix J provide guidance for making feasibility determinations). Where this is infeasible, biotreatment is allowed. In some limited cases, LID treatment reduction is allowed for certain smart growth, high density or transit-oriented development Special Projects, described below.

Biotreatment systems are landscape-based treatment measures that filter water through soils that are engineered to have a long-term infiltration rate of 5 to 10 inches per hour, in accordance with the soil specifications approved by the Regional Water Board in Appendix L. Biotreatment systems must have a surface area no smaller than what is required to accommodate a 5 inches per hour stormwater runoff surface loading rate. Biotreatment systems include an underdrain in a rock layer below the engineered soil, and are used in locations where it is infeasible to infiltrate the full amount of runoff specified in Provision C.3.d. Except in locations where infiltration is precluded, the underdrain should be in the upper portion of the rock layer, in order to maximize infiltration.

LID treatment requirements are reduced for certain smart growth, high density, or transit-oriented development ***Special Projects***. LID treatment reductions are provided in terms of a percentage of the total C.3.d amount of runoff that requires treatment. The percentage that is not treated with LID must be treated with either a high flow rate tree well filter, or a high flow rate media filter. The criteria and procedures for identifying Special Projects and calculating the percentage of LID treatment reduction are provided in Appendix K.

"DEEMED COMPLETE" EXCLUSIONS

- Development applications "deemed complete" for review by the planning department before December 1, 2009 and "diligently pursued[2]" by the project applicant will not be affected by the requirements that are effective December 1, 2011.
- Development applications that were "deemed complete" for review, by the planning department, after December 1, 2009, but receive final discretionary approval before ***December 1, 2011*** are not affected by the requirements that are effective December 1, 2011.

[2] Diligent pursuance may be demonstrated by the project applicant's submittal of supplemental information to the original application, plans, or other documents required for any necessary approvals of the project.

HYDROMODIFICATION MANAGEMENT REQUIREMENTS

Projects that create and/or replace ***one acre or more*** of impervious surface and increase impervious surface area over the pre-project condition need to incorporate hydromodification management measures, if the project is located in an area susceptible to hydromodification.

REDEVELOPMENT PROJECTS

If your project is located on a previously developed site and will result in the ***replacement of impervious surface***, then it is considered a redevelopment project and the following special provisions apply to it:

- ***"50 Percent Rule:"*** Projects that replace 50 percent or less of existing impervious surface need to treat stormwater runoff only from the portion of the site that is redeveloped. Projects that replace more than 50 percent of the existing impervious surface are required to treat runoff from the entire site.
- A project that does not increase impervious surface over the pre-project condition is not a hydromodification management (HM) project.

ROAD PROJECTS

If your roadway project (includes sidewalks and bicycle lanes built as part of new streets or roads) creates 10,000 square feet or more of newly constructed, contiguous impervious surface, the project is subject to the requirements of Provision C.3. Impervious trails 10 feet wide or more that are constructed within 50 feet of the top of a creekbank are also considered roadway projects. If the roadway project widens existing roads with additional traffic lanes, the ***"50 Percent Rule"*** for stormwater treatment (see above) applies. Road projects excluded from Provision C.3 are listed in Table 2-1.

ALTERNATIVE COMPLIANCE

The municipal stormwater permit allows projects to use "alternative compliance," to meet stormwater treatment requirements offsite. See Chapter 9 for more information.

HOW DO PROJECTS MEET THE C.3 REQUIREMENTS?

Your permit application submittals must include detailed information showing how the Provision C.3 stormwater requirements will be met. Chapter 3 provides step-by-step instructions for incorporating C.3 stormwater submittals into your permit application.

2.3.3 Upcoming C.3 Requirements - Effective December 1, 2012

Upcoming stormwater requirements for development projects are described below. The schedule of implementation is shown in Figure 2-5.

Beginning ***December 1, 2012***, all projects which create and/or replace 2,500 sq. ft. to 10,000 sq. ft., including detached single-family residences that are not part of a larger plan of development, must implement one or more of the following:

- Direct roof runoff into cisterns or rain barrels for reuse.
- Direct roof runoff onto vegetated areas.
- Direct runoff from sidewalks, walkways, and/or patios onto vegetated areas.
- Direct runoff from driveways and/or uncovered parking lots onto vegetated areas.

- Construct sidewalks, walkways, and/or patios with permeable surfaces.
- Construct bike lanes, driveways, and/or uncovered parking lots with permeable surfaces.

The Clean Water Program is currently participating in regional collaboration to prepare standard specifications for stormwater controls for projects that create and/or replace 2,500 to 10,000 square feet of impervious surface, and individual single family homes that create and/or replace 2,500 square feet or more of impervious surface. These projects will need to implement at least one of the specified stormwater controls beginning December 1, 2012, as required by MRP Provision C.3.i.

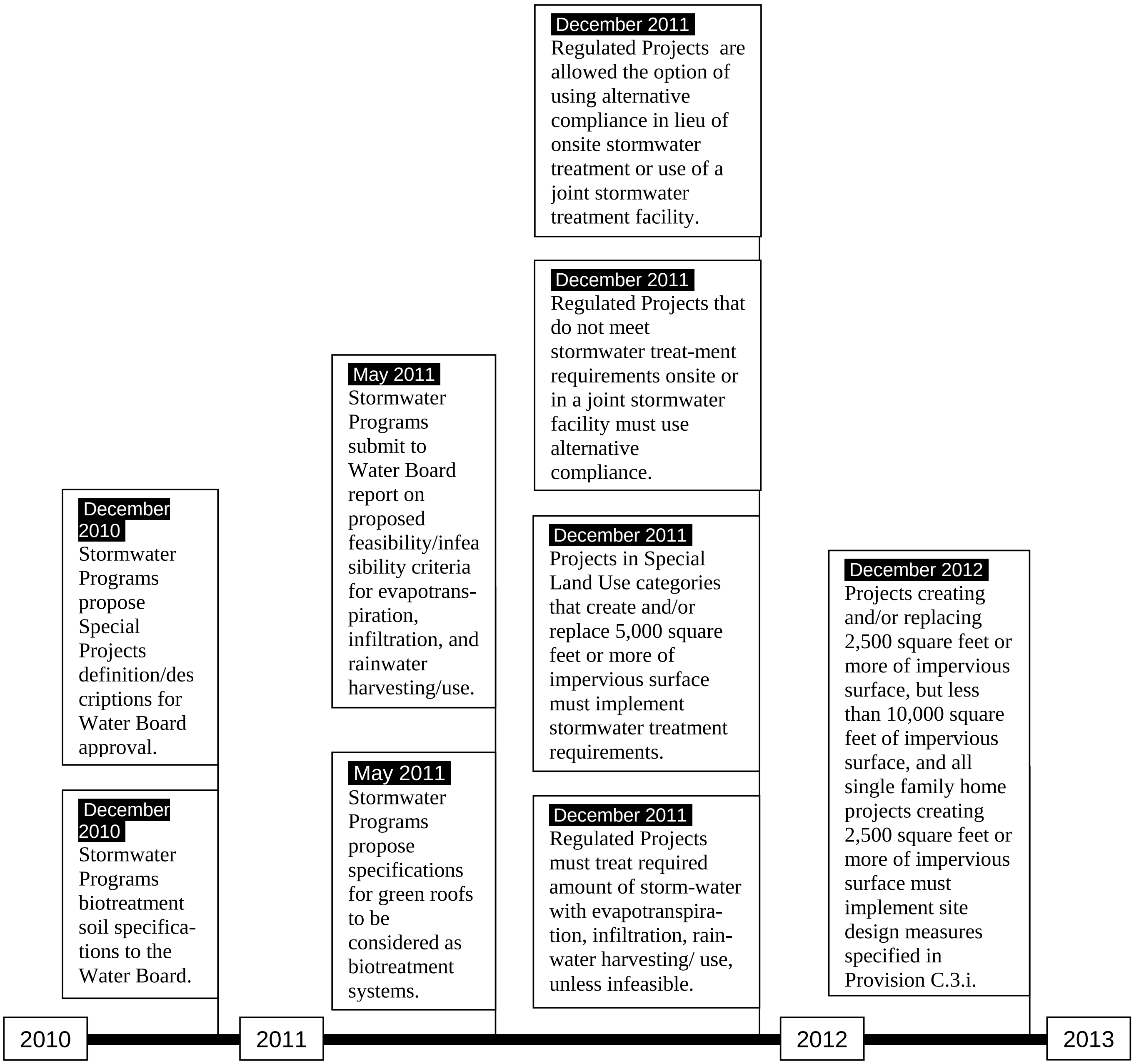

Figure 2-5: Timeline for Implementing New Provision C.3 Requirements

Chapter 3

Preparing Permit Application Submittals

This Chapter outlines the development review process and gives step-by-step instructions for preparing C.3 stormwater submittals for planning and building permit applications.

3.1 The Development Review Process

The municipalities have integrated their review of post-construction stormwater controls into the development review process. If the C.3 requirements apply to your project, your planning permit application submittal must show how you have incorporated the required post-construction stormwater controls. Section 3.2 gives step-by-step instructions on how to do this, beginning at the earliest phases of project planning. Some smaller projects may not require planning permits; see Section 3.4 for ***simple instructions for small sites***.

Preparing the preliminary design of stormwater controls simultaneously with the ***preliminary site plan*** and the landscaping plan is advised to achieve the following benefits:

- Maximize the stormwater benefits of project landscaping.
- Reduce overall project costs.
- Improve site aesthetics and produce a better quality project
- Speed project review times.
- Avoid unnecessary redesign.

> Preparing the preliminary design of stormwater controls simultaneously with the ***preliminary site plan*** and the landscaping plan can help reduce overall project costs.

After the municipality issues your planning permit, you will need to incorporate the required stormwater information into your building permit application submittal. Section 3.3 gives step-by-step instructions for preparing this submittal. A simplified diagram of a sample development review process is shown in Figure 3-1. Please note that the actual development review process in any of the municipalities may differ from the example.

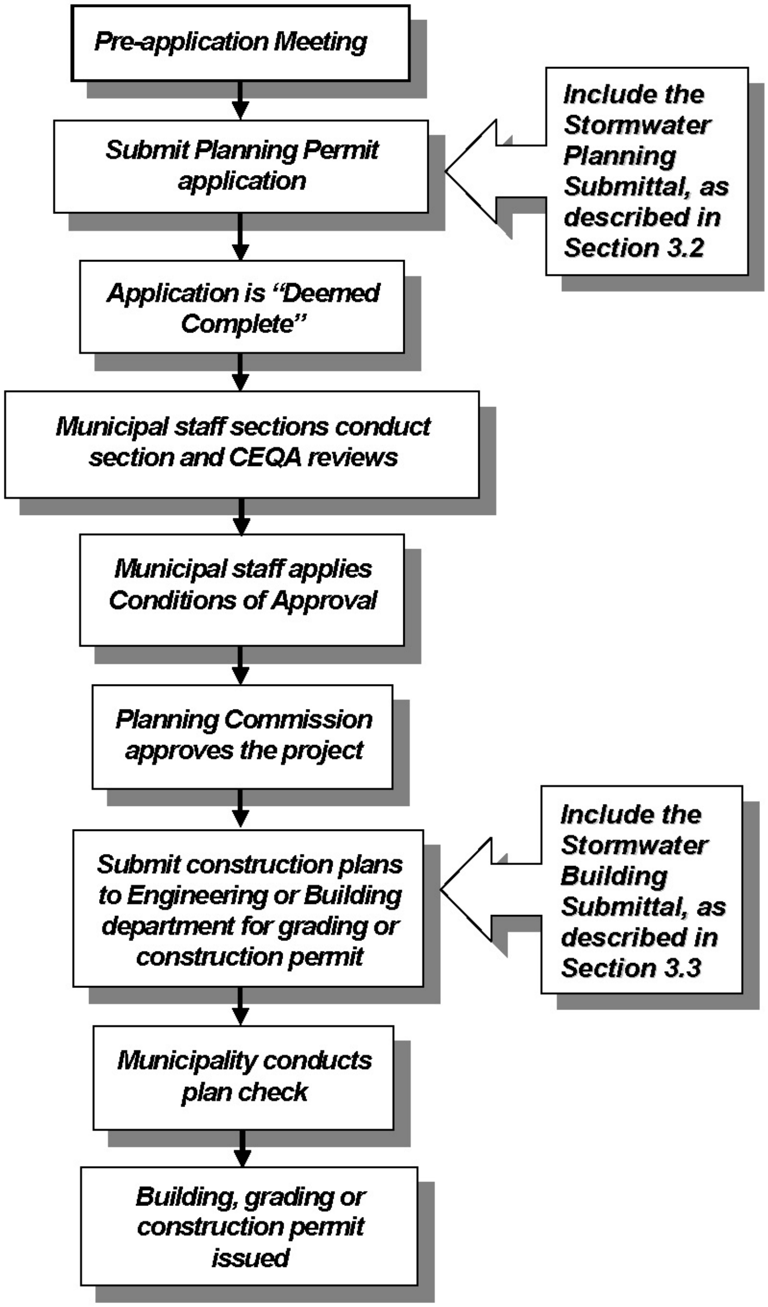

Figure 3-1: Sample Development Review Process

Although the development review process may vary from one municipality to the next, Figure 3-1 highlights the steps in the development review process at which municipalities typically require submittals showing how your project incorporates post-construction stormwater controls. These submittals are incorporated into your planning permit and building permit applications. Remember that the C.3 submittals show how the project will incorporate post-construction stormwater controls, to reduce pollutant loading and prevent increases in creek channel erosion during ***long-term project operations***. The municipality will require you to prepare separate documents to show how sedimentation and erosion will be controlled ***during construction***. Sections 3.2 and 3.3 present step-by-step instructions for preparing C.3 stormwater submittals for planning and building permit applications.

3.2 How to Prepare Planning Permit Submittals

A Planning Permit Submittal Checklist is provided below to help identify the C.3 stormwater-related items that you will need to submit with your planning permit application, but it's important to contact the planning staff of your local jurisdiction to discuss the specific requirements that may apply to your project. After you have a complete list of submittal requirements, you can use the Step-by-Step instructions in this section to prepare your submittal. Applicants with smaller projects are encouraged to read Section 3.4, "***Simple Instructions for Small Sites***," before using the Step-by-Step instructions.

C.3 submittals show how the project will reduce pollutant loading and prevent increases in creek channel erosion during ***long-term project operations***. You will need to prepare separate documents to show how sedimentation and erosion will be controlled during construction.

3.2.1 The Planning Permit Submittal Checklist

Table 3-1 presents a checklist of C.3 post-construction stormwater information that is typically submitted with planning permit applications. Please note that if runoff from your site discharges directly to a creek or wetland without flowing through a municipality-owned storm drain, you may need to submit additional information. Municipal staff may use this checklist to determine whether your submittal is complete, or some jurisdictions may use a modified checklist. The items included in this checklist are important to demonstrate that your project will:

- Incorporate ***site design measures*** to reduce impervious surfaces, promote infiltration and reduce water quality impacts;
- *Apply* ***source control measures*** to keep pollutants out of stormwater runoff;
- Use *stormwater* ***treatment measures*** to remove pollutants from stormwater; and
- Where applicable, manage ***hydromodification*** *(erosion-inducing flows)* by reducing the rate and amount of runoff.

Table 3-1
Planning Permit Submittal Checklist

Required?[1] Yes	No	Information on Project Drawings	Corresponding Planning Step (Section 3.2)
❑	❑	Existing natural hydrologic features (depressions, watercourses, relatively undisturbed areas) and significant natural resources.	Step 1
❑	❑	Depth to groundwater and soil saturated hydraulic conductivity or soil types.	Step 1
❑	❑	Existing and proposed site drainage network and connections to drainage offsite.	Step 1
❑	❑	For more complex drainage networks, show separate drainage management areas in the existing and proposed site drainage network.	Step 1
❑	❑	Existing condition, including pervious and impervious areas, for each drainage management area.	Step 1
❑	❑	Proposed pervious surfaces, including sensitive natural areas to be preserved and protected from development (for each drainage management area).	Steps 2 and 3
❑	❑	Proposed impervious surfaces, e.g., roof, plaza, sidewalk, street, parking lot (for each drainage management area).	Step 4
❑	❑	Proposed site design measures to minimize impervious surfaces and promote infiltration[2], which will affect the size of treatment measures.	Step 4
❑	❑	Proposed locations and approximate sizes of stormwater treatment measures and (if 1 acre or more of impervious surface is created) hydromodification management measures. Elevations should show sufficient hydraulic head for the treatment measures to work.[2]	Steps 5 - 9
❑	❑	Conceptual planting palette for stormwater treatment measures.[2]	Step 10
❑	❑	Pollutant source areas – including loading docks; food service areas; refuse areas; outdoor processes and storage; vehicle cleaning, repair or maintenance; fuel dispensing; equipment washing; etc. – and corresponding source controls from the local source control list.	Step 12
		Written Information on Municipal Forms or in Report Format	
❑	❑	Completed Impervious Surface Form (obtain from local agency).	Step 4
❑	❑	Completed Infiltration and Harvesting Use Feasibility Screening Worksheet, and, if applicable, the completed Rainwater Harvesting Feasibility Worksheet and/or Infiltration Feasibility Worksheet (obtain from local agency).	Steps 5 and 6
❑	❑	Preliminary calculations for each treatment and hydromodification management measure.	Step 9
❑	❑	Preliminary maintenance plan for stormwater treatment measures.	Step 11
❑	❑	List of source control measures included in the project.	Step 12

[1] Every item is not necessarily required for every project. Municipal staff may check the boxes in the “Required” column to indicate which items will be required for your project.

[2] Site design and treatment measures that promote stormwater infiltration should be consistent with recommendations of the project geotechnical engineer based on the soils boring data, drainage pattern and the current requirements for stormwater controls.

3.2.2 Planning Permit Submittals: Step-by-Step

Step-by-step instructions are offered below to help incorporate post-construction stormwater controls into your project from the very beginning of permit planning. The step-by-step instructions are intended to help you ***prepare the materials*** you will need to submit along with the planning permit application.

PLANNING PERMIT SUBMITTAL

Step 1: Collect Needed Information

Collecting the appropriate information is essential to selecting and siting post-construction stormwater measures. A list of the most ***commonly needed information*** is provided below, but municipal staff may request additional information as well.

- Existing natural features, especially ***hydrologic features*** including creeks, wetlands, watercourses, seeps, springs, ponds, lakes, areas of 100-year floodplain, and any contiguous natural areas. This information may be obtained by site inspections, a topographic survey of the site, and existing maps such as US Geologic Survey (USGS) quadrangle maps, Federal Emergency Management Agency (FEMA) floodplain maps, and US Fish and Wildlife Service (USFWS) wetland inventory maps.
- Existing site ***topography***, including the general direction of surface drainage, local high or low points or depressions, any steep slopes, outcrops, or other significant geologic features. This may be obtained from topographic maps and site inspections.
- ***Existing site drainage.*** For undeveloped sites, this would be identified based on the topographic information described above. For previously developed sites, information on drainage and storm drain connections may be obtained from municipal storm drain maps, plans for previous development, and site inspections.
- ***Soil types*** (including hydrologic soil groups) and ***depth to groundwater.*** If a soils report is not required for the project, planning-level information may be obtained from the Natural Resources Conservation Service (NRCS) Soils Survey. This information is used in determining the feasibility of onsite infiltration of stormwater.
- ***Existing impervious areas.*** Measuring the area of existing impervious surface is necessary to calculate the amount of impervious surface that will be replaced. The Clean Water Program's NPDES stormwater permit requires that redevelopment projects that replace 50 percent or more of impervious surface treat the stormwater runoff from the entire site, not just the redeveloped area. If less than 50 percent of existing impervious surface is replaced, and the existing development was not subject to stormwater treatment measures, then only the affected portion must be included in treatment measure design.
- ***Zoning*** information, including but not limited to requirements for setbacks and open space.

Review the information collected in Step 1. Identify the principal constraints on site design and stormwater treatment measure selection, as well as opportunities to reduce imperviousness and incorporate stormwater controls into the site and landscape

Constraints may include impermeable soils, high groundwater, steep slopes, geotechnical instability, high-intensity land use, or heavy vehicle traffic. ***Opportunities*** may include existing natural areas, low areas, oddly configured parcels, or landscape amenities.

design. For example, ***constraints*** might include impermeable soils, high groundwater, steep slopes, geotechnical inst ability, h igh-intensity land use , heavy vehicular tr affic, or safety concerns. ***Opportunities*** might include existing natural areas, low areas, oddly configured of otherwise unbuildable parcels, landscape amenities including open space and buffers (which can double as lo cations for st ormwater treatment measu res) a nd differences in elevat ion (which can provide hydraulic head for treatment measures). Pr epare a table or brief written summary of constraints and opportunities can prove helpful in selecting and siting stormwater controls.

PLANNING PERMIT SUBMITTAL

Step 2: Minimize Site Disturbance and Protect Sensitive Areas

Design the site layout to minimize changes to the natural topography. Using the information collected in Step 1, ide ntify any existing sensitive na tural res ources on th e site t hat w ill be protected and preserved from development. These may include the following types of areas:

- Development should be set back from ***creeks and riparian habitat*** as required by the local jurisdiction. If your project involves impacts to creeks and riparian habitat, contact the Water Board staff regarding permit and mitigation requirements.
- If the project includes ***wetlands*** subject to Section 404 of the federal Clean Water Act, or habitat for ***special-status species*** protected by federal or State laws, these areas should be indicated, and evidence should be pr ovided to demo nstrate complia nce wit h t he applicable laws.
- The pr oject will ne ed to comply with any lo cal tr ee pre servation ord inances and ot her policies p rotecting ***heritage or significant trees***. Mature tree s off er sub stantial stormwater benefits, and their preservation is recommended, where feasible, even if it is not required by law.
- The project needs to comply with any local restrictions on development of ***steep slopes*** and soils that are susceptible to ***erosion***. Even where not required by law, the avoidance of such areas is advisable in order to reduce stormwater impacts.

PLANNING PERMIT SUBMITTAL

Step 3: Incorporate Site Design Measures

Design the project to min imize the overall coverage of imperv ious paving a nd roofs, with a special focus on reducing the amount of impervious area that is directly connected to the storm drain system. Using site design measures to reduce impervious surfaces on your site can ***reduce the size of stormwater treatment measures*** that you will ne ed to install. But remember: even vegetated areas will generate some runoff. If runoff from landscaped areas flows to a stormwater treatment measure, that treatment measure will need to be sized to handle these relatively small amounts of runoff, as well as runoff from impervious surfaces. The use of self-treating areas (described below) can reduce the size of treatment mea sures even further.

> Using site design measures to reduce impervious surfaces on your site can ***reduce the size*** of stormwater treatment measures that you will need to install.

Some exam ples of sit e d esign mea sures ar e shown in Figures 3-2 and 3-3. You can find other photographs of site d esign measures in the C lean W ater Program's Gu idebook of Po st-Construction BM P Examples, at www.cleanwaterprogram.org (click on "Businesses", then "Development Related Issues"). More information on site design measures is provided in Chapter 4. A range of site design examples are described in the following list:

- Use ***alternative site layout techniques*** to reduce the total amount of impervious area. This may include designing compact, multi-story structures or clustering buildings. Some cities may allow narrow streets and (in very low-density neighborhoods) sidewalks on only one side of the street.
- ***Minimize surface parking*** areas, in terms of the number and size of parking spaces.

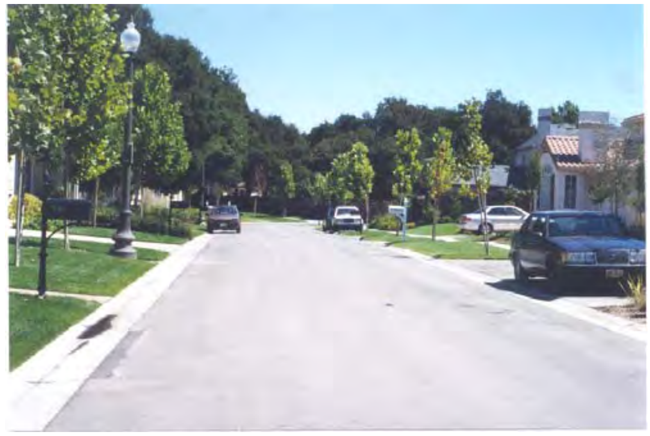

Figure 3-2: Example of a narrow street with parking pull-outs

- Use ***rainwater as a resource.*** Capturing and retaining roof runoff in cisterns can be a practical way to reduce the amount of runoff from the site and store rainwater for use in on-site irrigation. Stormwater storage provided by cisterns may be used to reduce the amount of stormwater that must be treated and, where applicable, retained on-site to meet hydromodification management requirements.
- Use ***drainage as a design element.*** Vegetated swales, depressed landscape areas, vegetated buffers, and bioretention areas can serve as visual amenities and focal points in the landscape design of your site.

Figure 3-3: Pleasanton Sports Park includes this turf block fire access road.

- ***Maximize choices for mobility.*** Motor vehicles are a major source of pollutants in stormwater runoff. Projects should promote, or at least accommodate, modes of transportation other than the automobile.
- Include alternative, pervious surfaces. ***Green roofs*** can partially or fully replace traditional roofing materials. ***Pervious surfaces*** such as crushed aggregate, turf block, unit pavers, or pervious paving – for sidewalks, parking lots, and low-volume residential areas. Green roofs and areas of pervious paving may be designed to function as self-treating areas (see next bullet).
- Identify ***self-treating areas.*** Some portions of your site may provide "self-treatment" if properly designed and drained. Such areas may include conserved natural spaces, large

landscaped areas (such as parks and lawns), green roofs and areas of pervious paving. These areas are considered "self-treating" because infiltration and natural processes that occur in these areas remove pollutants from stormwater. As long as the self-treating areas do ***not receive runoff from impervious areas*** on the site, your drainage design may direct the runoff from self-treating areas directly to the storm drain system or other receiving water. More information on self-treating areas is given in Chapter 4.

- Direct ***runoff to depressed landscaped areas.*** You may be able to design an area within your site to function as a "self-retaining area," in which the amount of stormwater runoff that is required to be treated is infiltrated or retained in depressed landscaped areas. A 2:1 ratio of impervious area to the receiving pervious area may be acceptable, where soils permit. Much higher ratios are possible if the runoff is directed to a bioretention area or other landscape-based treatment measures. See Section 4.

PLANNING PERMIT SUBMITTAL

Step 4: Measure Pervious and Impervious Surfaces

Stormwater treatment is required for projects that create and/or replace ***10,000 square feet*** or more of impervious surface – with some exceptions that are listed in Chapter 2. Effective December 1, 2011, the threshold for requiring stormwater treatment is reduced from 10,000 to ***5,000 square feet,*** or more, of impervious surface for the following project categories: uncovered parking areas (stand-alone or part of another use), restaurants, auto service facilities[1], and retail gasoline outlets. The 5,000 square foot threshold will not apply if a) the project was deemed complete on or before December 1, 2009, and the applicant has diligently pursued[2] the project; b) the project is deemed complete after December 1, 2011, but receives final discretionary approval before December 1, 2011; and/or c) it is a public project for which funding has been committed and construction is scheduled to begin by December 2, 2012.

Hydromodification management (HM) is required for projects that create and/or replace one acre or more of impervious surface AND are located in susceptible areas as identified in the Hydromodification Management Susceptibility Map (see Appendix I). Section 7.1 describes this map, and Section 7.2 lists exceptions to the requirements.

The ***Impervious Surface Form*** that is provided by the local jurisdiction must be completed as part of the planning permit application submittal. This form is used to calculate the amount of impervious surface that will be created and/or replaced, and determine whether treatment and/or HM measures are required. Impervious surfaces are those areas in which

[1] Auto service facilities include the specific Standard Industrial Classification Codes, as follows:
5013: Wholesale distribution of motor vehicle supplies, accessories, tools, equipment, and parts.
5014: Wholesale distribution of tires and tubes for passenger and commercial vehicles.
7532: Repair of automotive tops, bodies, and interiors, or automotive painting and refinishing.
7533: Installation, repair, or sale and installation of automotive exhaust systems.
7534: Repairing and retreading automotive tires.
7536: Installation, repair, or sales and installation of automotive glass.
7537: Installation, repair, or sales and installation of automotive transmissions.
7538: General automotive repair.
7539: Specialized automotive repair such as fuel service, brake relining, front-end and wheel alignment, and radiator repair.

[2] Diligent pursuance may be demonstrated by the project applicant's submittal of supplemental information to the original application, plans, or other documents required for any necessary approvals of the project by the reviewing jurisdiction.

development prevents water from infiltrating into the ground and results in runoff. Impervious surfaces include but are not limited to:

- Footprints of all buildings and structures, including garages, carports, sheds, etc.;
- Driveways, patios, parking lots, decking;
- Streets and sidewalks.

Areas of pervious paving that are underlain with pervious soil or pervious storage material, such as a gravel layer sufficient to hold at least the Provision C.3.d volume of rainfall runoff are not considered impervious surfaces, and are excluded from the calculation of impervious surfaces.

Projects that do not meet the size thresholds for impervious surface need to include stormwater treatment measures (Steps 5, 6, and 7) to the maximum extent practicable – and the Provision C.3 numeric sizing criteria may not apply. Check with the local jurisdiction to determine whether Steps 5 through 7 will apply to your project.

PLANNING PERMIT SUBMITTAL

Step 5 : Determine if Special Projects LID treatment reduction credits apply

LID treatment reduction credits can be applied to smart growth, high density or transit oriented development projects that meet specific criteria for the Special Projects included in Appendix K. Contact municipal staff to determine whether your project meets the criteria to be considered a Special Project.

PLANNING PERMIT SUBMITTAL

Step 6: Determine if New Low Impact Development (LID) Requirements Apply

Stormwater treatment requirements must be met using evapotranspiration, infiltration, and/or rainwater harvesting and reuse. Where this is infeasible, biotreatment measures may be used. Refer to Appendix J for the feasibility worksheets and guidance based on regional criteria and procedures in order to determine feasibility at a site.

PLANNING PERMIT SUBMITTAL

Step 7: Select Treatment/HM Measures

There are many different types of treatment measures, each with particular advantages and disadvantages, and new innovative solutions continue to be developed. ***Chapter 6*** provides technical guidance for specific types of stormwater treatment measures that are commonly used in Alameda County. While other treatment measures may be approved, it may be possible to expedite the review of your project by closely following the guidance provided in Chapter 6.

Selecting the appropriate treatment measure(s) for a specific site is a matter of professional judgment. Some general factors to consider are offered below:

- Effective ***December 1, 2011***, vault-based systems are allowed only in a limited number of locations and types of development.
- Is ***Hydromodification management*** (HM) required? If your project needs to meet both treatment and HM requirements, it is recommended, to the extent feasible, that stormwater control measures be designed to meet both treatment and HM needs.

- ***Soil suitability.*** Soils are classified into four hydrologic soil groups – A, B, C, and D – with the soils in each group having similar runoff potential under similar storm and cover conditions. Group A soils generally have the lowest runoff potential, and group D have the greatest.[3] Treatment measures that rely primarily on ***infiltration***, such as *infiltration trenches*, are unsuitable for use in group D soils (clay loam, sandy clay and clay) and have the potential to fail in group C (silt loam) soils. Bioretention areas installed in group C and D soils typically require subdrains.
- ***Site slope.*** LID treatment measures need to be carefully selected and designed for use on steep slopes, because infiltration of stormwater runoff can cause geotechnical instability. Depending on site conditions, it may be possible to design ***bioretention areas*** using check dams for projects on sites with some slope constraints.
- ***Considerations for larger sites.*** For larger sites that can be divided into separate drainage areas, a variety of smaller stormwater treatment measures may be dispersed throughout the site. It may also be possible to route the stormwater runoff from an individual drainage area to a cistern for non-potable use, such as irrigation or flushing toilets (see Section 4.4, ***Rainwater Harvesting and Use***).
- Consider ***maintenance requirements.*** The amount of maintenance that a stormwater treatment measure will require should be considered when selecting treatment measures. As described in Section 3.3, you will need to prepare and submit a ***maintenance plan*** for stormwater treatment measures with the building permit application. Section 8.2 provides information regarding the maintenance requirements for various treatment measures.

> The ***mosquito control guidance*** (Appendix G) needs to be implemented for all stormwater treatment measures, with special consideration given to treatment measures that are designed to include standing water.

- ***Avoid mosquito problems.*** The mosquito control guidance provided in ***Appendix G*** needs to be implemented for all stormwater treatment measures, with special consideration given to treatment measures that are designed to include standing water.
- Potential for ***groundwater contamination.*** Before selecting an infiltration device, such as an infiltration trench, infiltration basin, or French drain, review the infiltration considerations presented in ***Appendix F*** to protect groundwater from contamination by pollutants in stormwater runoff.

PLANNING PERMIT SUBMITTAL

Step 8: Locate Treatment/HM Measures on the Site

Review the existing and proposed site drainage network and connections to drainage offsite, which were collected in Step 1. Selecting appropriate locations for treatment and HM measures involves a number of important factors, including the following:

- ***Design for gravity flow.*** If at all possible, treatment/HM measures should be designed so that drainage into and out of the treatment measure is by gravity flow. This promotes effective, low-maintenance operation and helps avoid mosquito problems. Pumped

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[3] Details of this soil classification can be found in the National Soil Survey Handbook, Part 618.35 (USDA, 2006), http://soils.usda.gov/technical/handbook.

systems can be feasible, but they are more expensive, require more maintenance, and can introduce sources of underground standing water that attract mosquito breeding.

- Determine ***final ownership and maintenance responsibility.*** Treatment measures should be available for ready access by maintenance workers, municipal inspectors, and staff from the Alameda County Mosquito Abatement District or the Alameda County Vector Control District. If the property will be subdivided, be sure to locate shared treatment measures in a common, accessible area – not on a private residential lot.
- Incorporate ***treatment measures in the landscape design.*** Almost every project includes landscaped areas. Most zoning districts require a certain amount of open space, and some require landscaped setbacks or buffers. It may be possible to locate some or all of your projects' treatment/HM measures within required landscape areas.
- ***Plan for maintenance.*** Stormwater treatment measures will need to be accessible to the largest piece of equipment that will be needed for maintenance. For example, bioretention areas and vegetated swales need access for the types of machinery used for landscape maintenance. Large extended detention basins need to have a perimeter access road accessible by heavy vehicles for sediment removal and controlling emergent vegetation. Underground treatment measures and media filters may require special equipment for periodic clean out and media replacement.

Figure 3-4: This sports field in Dublin also functions as a stomwater detention area.

PLANNING PERMIT SUBMITTAL
Step 9: Preliminary Design of Treatment/HM Measures

Perform preliminary design of the stormwater treatment measures you have selected using the hydraulic sizing criteria in Section 5.1 and the technical guidance for specific types of treatment measures in Chapter 6. The technical guidance in this handbook is compatible with the ***Bay Area Hydrology Model*** (BAHM), a tool for sizing HM measures, developed by the Clean Water Program in cooperation with the Santa Clara Valley Urban Runoff Pollution Prevention Program and the San Mateo Countywide Stormwater Pollution Prevention Program. The BAHM may be downloaded at www.bayareahydrologymodel.com. See Chapter 7 for more information on the BAHM and the design of HM measures.

Detailed construction drawings are typically not required for planning permit submittals, but drawings or sketches need to be included to illustrate the proposed design and sizing information based on runoff calculations.

> Selecting plants that can survive long periods with little or no rainfall will ***help reduce irrigation requirements.***

PLANNING PERMIT SUBMITTAL
Step 10: Consider Planting Palettes for Treatment Measures

The selection of appropriate plant materials is an important part of designing a successful landscape-based stormwater treatment measure. Plants need to be hardy, low-maintenance, tolerant of saturated soils, and selecting plants that can survive long periods with little or no rainfall will ***help reduce irrigation requirements***, although irrigation systems are typically required for landscape-based stormwater treatment measures. At the planning permit phase of the project a detailed planting plan is typically not required, but many municipalities require a conceptual planting palette. Appendix B provides guidance regarding the selection of plant materials for landscape-based treatment measures.

PLANNING PERMIT SUBMITTAL

Step 11: Prepare a Preliminary Maintenance Plan (if required)

A stormwater treatment measure maintenance plan describes how stormwater treatment measures will be maintained during the years and decades ***after construction is completed.*** In some cases a municipality may require the submittal of a preliminary maintenance plan as part of the planning permit submittal. Otherwise, a maintenance plan is required only as part of the building permit submittal. ***Check with your local jurisdiction*** regarding the requirements for your project.

A preliminary maintenance plan identifies the ***proposed maintenance activities***, and the intervals at which they will be conducted, for each stormwater treatment measure included in the project. As part of the building permit submittal, applicants will also need to provide additional information that will be included in a maintenance agreement between the local municipality and the property owner. Chapter 8 provides more information about stormwater treatment measure operation and maintenance. Maintenance plan templates for various types of stormwater treatment measures are included in Appendix H.

PLANNING PERMIT SUBMITTAL

Step 12: Use Applicable Source Control Measures

> Source control measures are land use or site planning practices, or operational activities, that aim to prevent runoff pollution by reducing the potential for contact with rainfall runoff at the source of pollution.

Pollutants are generated by many common activities that will occur after construction is completed. Each local jurisdiction has specific pollutant source control requirements for projects that include landscaping, swimming pools, vehicle washing areas, trash/recycling areas, and other sources of pollutants. These requirements are identified in the agency's ***Local Source Control Measures List.*** Be sure to obtain the current list from your local jurisdiction. The lists are typically divided in two parts: Part I - Structural Source Controls and Part II – Operational Source Controls. These two types of source controls are described as follows:

- ***Structural Source Controls*** - Structural source controls are permanent features that are designed and constructed as part of a project, such as sanitary sewer connections for restaurant wash areas that are large enough to wash the largest piece of equipment.
- ***Operational Source Controls*** – Operational source controls are "good housekeeping" activities that must be conducted routinely during the operations phase of the project – such as street sweeping and cleaning storm drain inlets.

Projects must incorporate the applicable source controls for any project activity that is included in the local source control lists. The following methods may be used to accomplish this.

- ***Review*** structural source controls in Part I of the local list and compare this list to your site plan. Identify any areas on the site that require structural source controls. Remember that some activities may not have been sited yet. For example, the Model List includes a requirement for enclosing and roofing refuse storage areas. If a designer was unaware of this requirement, it may not be shown on the project plans. .
- ***Incorporate*** all the required structural source controls on your project drawings.
- ***If required by the municipality,*** prepare and submit a table, listing in three columns the potential sources of pollutants, the permanent source control measures, and any operational source control measures from Part II of the local list that apply to the project. Table 3-2 is an example Table of Source Controls.

Table 3-2: Example Table of Stormwater Source Controls

Potential Source of Pollutants	Structural Source Controls	Operational Source Controls
On-site storm drains	On-site storm drains shall be marked with the words "No Dumping! Flows to Bay" (or applicable water body) applied with thermoplastic.	All on-site storm drain inlets shall be cleaned at least once a year immediately prior to the rainy season.
Refuse areas	New or redevelopment projects, such as food service facilities, recycling facilities or similar facilities, shall provide a roofed and enclosed area for dumpsters and recycling containers. The area shall be designed to prevent water run-on to the area and runoff from the area and to contain litter and trash, so that it is not dispersed by the wind or runoff during waste removal.	None

NOTE: This table is included as an example only and is not intended for use in an actual submittal.

PLANNING PERMIT SUBMITTAL

Step 13: Coordinate with Other Project Requirements

When submitting the C.3 stormwater drawings with the planning permit submittal, the stormwater site design, source control, treatment and HM measures may be shown on a separate stormwater plan, or combined with the site plan, landscaping plan, or drainage plan – depending on the complexity of the project. Whether plans are combined or separate, there are a number of issues that must be carefully coordinated with other aspects of the project design. Some typical coordination considerations are listed below.

- ***Balance of Cut and Fill.*** When calculating the overall project balance of cut and fill, be sure to include the excavation of stormwater treatment measures (including the need to replace existing clay soils with group A or B soils).
- ***Soil Compaction during Construction.*** Compaction from construction traffic can severely restrict the infiltration capacity of soils at your site. In the construction staging plan, protect and limit operation in those portions of the site that will accommodate self-treating areas or stormwater treatment measures that rely on infiltration.
- ***Building Drainage.*** Building codes require that drainage from roofs and other impervious areas be directed away from the building. The codes also specify minimum sizes and slopes for roof leaders and drain piping. Any stormwater measure located in or on the building, or that may affect building foundations, must be designed to meet the

minimum building code requirements. Stormwater treatment measures are also required to meet the requirements for detention or flow described in Section 5.1.

- ***Control of Elevations.*** Getting runoff to flow from impervious surfaces to landscaped surfaces may require greater attention to detailed slopes and elevations in grading and landscaping plans. For example:
  - ***Provide Adequate Change in Elevation*** between the pavement and vegetated areas. The landscaped area needs to be low enough so that runoff will flow into it even after the turf or other vegetation has grown up. If adequate reveal is not provided, runoff will tend to pond on the edge of the paved surface.
  - ***Provide for Differential Settlement.*** While the soil in landscaped-based stormwater treatment measures and self-treating areas must be left loose and uncompacted, concrete structures (such as inlets and outlets) must be supported on a firm foundation. If not, they may settle more than the surrounding ground, creating depressions that can hold standing water and contribute to mosquito breeding.
  - ***Prevent Erosion.*** Erosion may occur at points where the stormwater runoff flows from impervious areas into landscape-based treatment measures. Include in the project plans any proposed erosion controls, such as cobbles or splash blocks.
- ***Drainage Plans.*** The local building or engineering department may require a drainage plan, which typically focuses on preventing street flooding during a 10-year storm and demonstrating that flooding from 100-year storms can be managed. To meet the drainage plan requirements it may be necessary to include ***high flow bypasses*** in the design of stormwater treatment measures, in order to route ***flood flows*** directly to the storm drain system. Check with your local jurisdiction regarding the need to prepare a drainage plan, and whether it is required only as part of the building permit submittal, or if a preliminary drainage plan is needed with the planning permit submittal.
- ***Signage for Traffic and Parking.*** If your project includes depressed landscaped areas next to parking lots, driveways or roadways, it may be necessary to include bollards, striping or signs to guide traffic, especially if curbs are flush with the pavement. Traffic striping may not be practical for permeable pavements such as crushed aggregate and unit pavers. In these areas signs and bollards may be needed to help direct traffic.

Figure 3-5: Drain rock is used to prevent erosion of this vegetated swale at Zone 7 Water Agency's office building.

PLANNING PERMIT SUBMITTAL

Step 14: Submit Planning Permit Application

Assemble all the items listed in Table 3-1 that municipal staff indicates are required for your project, and include them as attachments to the planning permit application for your project.

3.3 Building Permit Submittals

> If your project ***does not require a planning permit***, submit items from both Tables 3-1 and 3-3 with the building permit application.

Except for projects on small sites, the principal differences between planning permit submittals and building permit submittals are:

- ***Construction level detail*** is needed, rather than preliminary plans;
- ***Highlight and explain changes***, if plans differ from the planning permit submittal;
- Include ***detailed maintenance plans*** and documentation for maintenance agreement.

Table 3-3 provides a list of materials that may be required at this stage in the project, followed by brief step-by-step instructions.

Table 3-3: Building Permit Submittal Checklist

Required? Yes	No	Information on Project Drawings	Corresponds to Building Step (Sect. 3.3)
❑	❑	Sensitive natural areas to be preserved and protected from development. – highlighting any changes since the planning permit submittal.	Step 1
❑	❑	Proposed impervious surfaces, e.g., roof, sidewalk, street, parking lot (for each drainage area) – highlight any changes since the planning permit submittal.	Step 1
❑	❑	Site design measures to minimize impervious surfaces and promote infiltration – construction level detail.	Step 1
❑	❑	Construction level detail of stormwater treatment measures and (if 1 acre or more of impervious surface is created) hydromodification management measures.	Step 1
❑	❑	Pollutant source areas and corresponding structural source controls from local source control list – construction level detail.	Step 1
❑	❑	Landscaping plan for stormwater treatment measures–construction level detail.	Step 1
❑	❑	Letter- or legal-sized conceptual or site plan showing locations of storm-water treatment measures, for inclusion in the Maintenance Agreement.	Step 2
		Written Information on Municipal Forms or in Report Format	
❑	❑	Completed Impervious Surface Form, showing any changes since planning permit submittal.	Step 1
❑	❑	Detailed hydraulic sizing calculations for each treatment and/or hydromodification management measure.	Step 1
❑	❑	List of source control measures included in the project, showing any changes since planning permit submittal.	Step 1
❑	❑	Detailed maintenance plan for stormwater treatment measures, including inspection checklists, as appropriate.	Step 2
❑	❑	A standard treatment measure O&M report form, to be attached to the Maintenance Agreement	Step 2

BUILDING PERMIT SUBMITTAL
Step 1: Update Project Documentation

Information regarding the design of stormwater measures that was submitted with the planning permit application must be updated, as necessary, for submittal with the building permit application. Specific requirements may vary in the various jurisdictions, but this is anticipated to include the following:

- Incorporate all ***stormwater-related conditions of approval*** that were applied during planning permit review.
- Highlight and explain any ***other stormwater-related changes*** that have been made since the planning review. This may include, but is not limited to, changes in the boundaries of sensitive areas to be protected, changes in the amount of impervious surface to be created/replaced, changes in the stormwater pollutant source areas, changes in the location or design of stormwater measures, etc.
- Prepare ***construction level detail*** for all stormwater measures included in the project.
- Prepare detailed ***hydraulic sizing calculations*** for stormwater treatment and HM measures, using the hydraulic sizing guidance provided in Section 5.1.
- Prepare construction-level ***planting plans*** for landscape-based stormwater treatment measures.

NOTE: Some ***smaller projects*** may not require a planning permit. If this is true for your project, your building permit application submittal will need to include items listed in both Table 3-1 and Table 3-3. Ask the building department staff to help you identify the specific items needed for your submittal.

BUILDING PERMIT SUBMITTAL
Step 2: Prepare Maintenance Documentation

Property owners are responsible for assuring the long-term operation and maintenance of a project's stormwater treatment measures, unless the applicable municipality approves other specific arrangements. Details may vary from one jurisdiction to another, but ***maintenance agreements*** generally require the property owner to assure that all stormwater treatment measures receive proper maintenance in accordance with an approved maintenance plan; that municipal, Water Board, Mosquito Abatement District, and Vector Control District staff be granted access, as needed, to ensure proper maintenance and operation; and if the property owner fails to maintain the treatment measure, municipal staff be allowed to enter the property, perform necessary emergency repairs, and charge the property owner for the necessary emergency repairs. Project applicants are typically required to provide the following documentation to support the maintenance agreement:

- A ***conceptual plan or site plan*** that is legible on letter- or legal-sized paper (8.5-by-11 inches or 8.5-by-14 inches) and shows the locations of the stormwater treatment measures that will be subject to the agreement. ***Some municipalities have specific requirements*** for these plans, such as requiring a conceptual plan that includes only the stormwater treatment measures. If more than one stormwater treatment measure is used, the treatment measures should be numbered for ease of identification (for example, Swale 1, Swale 2, etc.)

- A ***maintenance plan*** that includes specific long-term maintenance tasks and a schedule. Section 8.2 provides guidance for preparing a maintenance plan, and Appendix H features maintenance plan templates to use when preparing a maintenance plan. If a preliminary maintenance plan was submitted with the planning permit application, this plan should be updated to respond to municipal staff comments and include a sufficient level of detail for implementation.

- A Standard Treatment Measure Operation and Maintenance ***Inspection Report Form***, which some municipalities require the property owner to complete and submit to the municipality each year. The purpose the annual report is to help the municipality verify that appropriate O&M is occurring. A template for preparing this report form is included in Appendix H.

BUILDING PERMIT SUBMITTAL

Step 3: Submit Building Application

Assemble all the items listed in Table 3-3 that municipal staff has indicated are required for your project, and include them as attachments to your building permit application.

3.4 Simple Instructions for Small Sites

Some developers of smaller projects may be less familiar with requirements to incorporate stormwater treatment measures. If you are a qualified engineer, architect or landscape architect, you may be able to prepare the entire C.3 submittal yourself. If not, you will probably need to hire a ***qualified civil engineer, architect or landscape architect*** to prepare the submittal – or at least some of the more technical aspects of the submittal. Some tips for smaller projects are provided below:

- ***Review submittal checklists with municipal staff.*** If your project does not require a planning permit, you will need to include in your building permit application submittal some of the items that are listed in Table 3-1 (Planning Permit Submittal Checklist) and some from Table 3-3 (Building Permit Checklist). But remember, not every item in the checklists is required for every project. Make an appointment with a member of the building department staff to sit down and go through the checklists with you, to give you a ***reduced list*** of the items you will need for your small site. And make sure to get the list in writing, so you can refer to it, if necessary, in future conversations with municipal staff. If your project requires a planning permit, use this same strategy to get a list of required items from the planning staff.

- ***Maximize the use of site design measures.*** The less impervious surface area on the site, the smaller your stormwater treatment measures will need to be. Chapter 4 lists strategies for reducing impervious surfaces, and it offers guidance for using self-treating areas (for example, landscaping, areas paved with turf block, or green roofs) to further

reduce the size of treatment measures. Beginning ***December 1, 2012***, projects that create and/or replace at least 2,500 but less than 10,000 square feet of impervious surface will be required to incorporate site design measures, using specifications that will be included in Appendix M.

- ***Use LID treatment measures.*** Even on small sites, LID treatment measures are required, except for projects that may receive LID treatment reduction credits as a Special Project (described in Appendix K). Chapter 6 includes technical guidance for some treatment measures, such as bioretention areas and flow-through planters, which are well suited for small sites in ***densely developed areas***. Where on-site conditions, such as proximity to buildings, high groundwater or contaminated soils prohibit infiltration, flow-through planters may be a good option.

- ***Consider using simplified sizing methods.*** The technical guidance in Chapter 6 includes simplified sizing methods for several types of stormwater treatment measures, including vegetated swales, flow-through planters, and bioretention areas. The technical guidance for each of these treatment measures highlights the easy-to-follow calculations for sizing the treatment measures. Please note, however, that there is a trade-off for simplicity. The simplified sizing calculations may result in treatment measures that are conservatively large. If space is at a premium, it may be cost-effective to hire a civil engineer with experience sizing stormwater treatment measures and use the more detailed sizing calculations, in order to potentially reduce the amount of land needed for stormwater treatment.

Figure 3-6: Flow-through planters are incorporated into the landscaping in a dense, urban setting in Emeryville.

- ***Use the planting guidance.*** Appendix B provides guidance for selecting appropriate plantings for landscape-based stormwater treatment measures. Municipal staff will check to confirm that the plants included in your design meet the criteria set forth in this guidance.

Chapter

4

Site Design Measures

This Chapter explains how site design measures can reduce the size of your project's stormwater treatment measures.

Site design measures for water quality protection are low impact development (LID) techniques employed in the design of a project site in order to reduce the project's impact on water quality and beneficial uses. Site design measures are not treatment measures. Including site design measures in a project does not meet the C.3 requirements for stormwater treatment, but it can help reduce the size of treatment measures (see Section 4.1). Site design measures can be grouped into two categories:

- Site design measures that ***preserve sensitive areas*** and high quality open space**,** and
- Site design measures that ***reduce impervious surfaces*** in a project.

This chapter emphasizes site design measures that reduce impervious surfaces, which can reduce the amount of stormwater runoff that will require treatment. This translates into smaller facilities to meet stormwater treatment requirements than would have been needed without the site design measures. Site design measures are also important in minimizing the size of any required hydromodification management measures for the site. A wide variety of site design measures can be incorporated in your project, including:

- Design ***self-treating*** areas and ***self-retaining*** areas.
- ***Reduce the size of impervious features*** in the project.
- Use cisterns or rain barrels to ***store rainwater*** onsite.
- Preserve and plant trees.

Site design measures used to reduce the size of stormwater treatment measures ***must not be removed*** from the project without a corresponding resizing of the stormwater treatment measures.

Where landscaped areas are designed to have a stormwater drainage function, they need to be carefully integrated with other landscaping features on the site early in project design. This may require coordinating separate designs prepared by different professionals.

Remember that any site design measures (including self-treating areas) used to reduce the size of stormwater treatment measures ***must not be removed*** from the project without a corresponding resizing of the stormwater treatment measures. For this reason, your municipality may require you to include site design measures in the maintenance agreement or maintenance plan for stormwater treatment measures, or otherwise record them with the deed. Depending on the municipality, site design measures may be subject to periodic operation and maintenance inspections. Check with the municipal staff regarding the local requirements.

4.1 Using Self-Treating Areas

Some portions of your site may provide "self-treatment" if properly designed and drained. Such areas may include conserved natural spaces, landscaped areas (such as parks and lawns), green roofs, and areas paved with turf block. Areas of pervious pavement – such as porous concrete, porous asphalt, or unit block pavers – may function as self-treating areas if they are designed to store and infiltrate the rainfall runoff volume described in Provision C.3.d of the MRP. These areas are considered "self-treating" because infiltration and ***natural processes that occur in these areas remove pollutants*** from storm water. Technical guidance for green roofs, pervious pavement, turf block, and permeable joint pavers is provided in Chapter 6.

> If self-treating areas do not receive runoff from impervious areas, runoff from self-treating areas may discharge ***directly*** to the storm drain.

As long as the self-treating areas are not used to receive runoff from other impervious areas on the site, your drainage design may route the runoff from self-treating areas ***directly to the storm drain*** system or other receiving water. Thus, the stormwater from the self-treating areas is kept separate from the runoff from paved and roofed areas of the site, which requires treatment.

Even vegetated areas will generate some runoff. ***If runoff from a self-treating area co-mingles with the C.3.d amount of runoff from impervious surfaces***, then your stormwater treatment measure must be hydraulically sized to treat runoff from both the self-treating area and the impervious areas. This does not apply to the high flows of stormwater that are in excess of the C.3.d amount of runoff, because stormwater treatment measures are not designed to treat these high flows. If your project requires hydromodification management, then the runoff from self-treating areas will need to be included in the sizing calculations for HM treatment measures.

Figure 4-1 compares the size of the stormwater treatment measure that would be required to treat the runoff from a site, depending on whether or not the runoff from a self-treating area discharges directly to the storm drain system or other receiving water. In the first (upper) sequence, runoff from the self-treating area is directed to the stormwater treatment measure. In the second (lower) sequence, runoff from the self-treating area bypasses the treatment measure and flows directly to the storm drain system or other receiving water, resulting in a smaller volume of stormwater that will require treatment. This results in a ***smaller stormwater treatment measure***.

Figure 4-2 compares the conventional drainage approach to the self-treating area approach. The conventional approach combines stormwater runoff from landscaped areas with the runoff from impervious surfaces. Assuming the parking lot storm drain leads to a treatment measure, in the conventional approach, the treatment measure will need to be sized to treat runoff from the entire site. The ***self-treating area approach*** routes runoff from the landscaped areas directly to the storm drain system. In this approach, the treatment measure is sized to treat only the runoff from impervious areas.

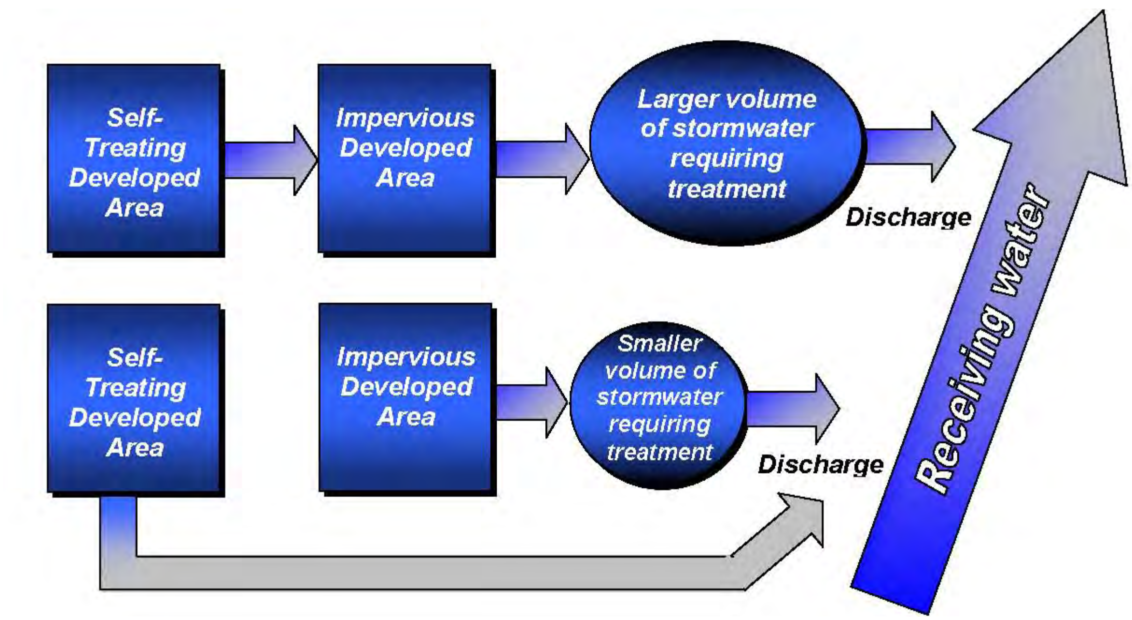
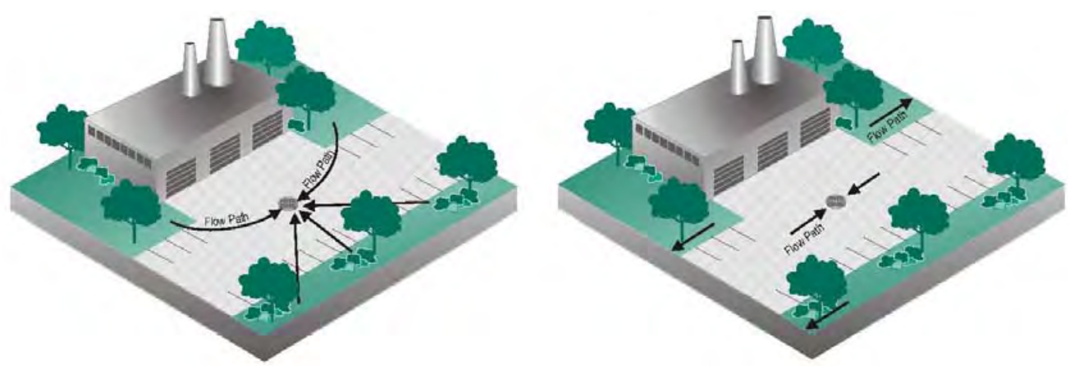


Figure 4-1: Self-Treating Area Usage (Source, BASMAA, 2003)



Conventional Drainage Approach **Self-Treating Area Approach**

Figure 4-2: Commercial/Industrial Site Compared to Same Site with Self-Treating Areas (Source, BASMAA 2003)

Figure 4-3 shows an example site in which the runoff from impervious areas must flow to the stormwater treatment measure before discharging to the storm drain, while runoff from the self-treating area may discharge directly to the storm drain. This is allowable because the self-treating area does not accept runoff from the impervious portions of the site.

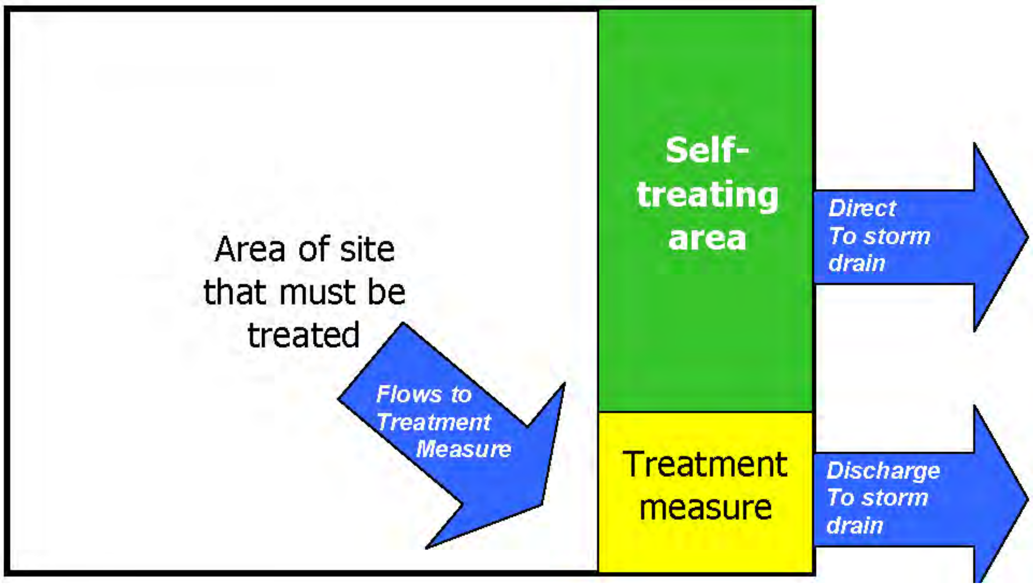


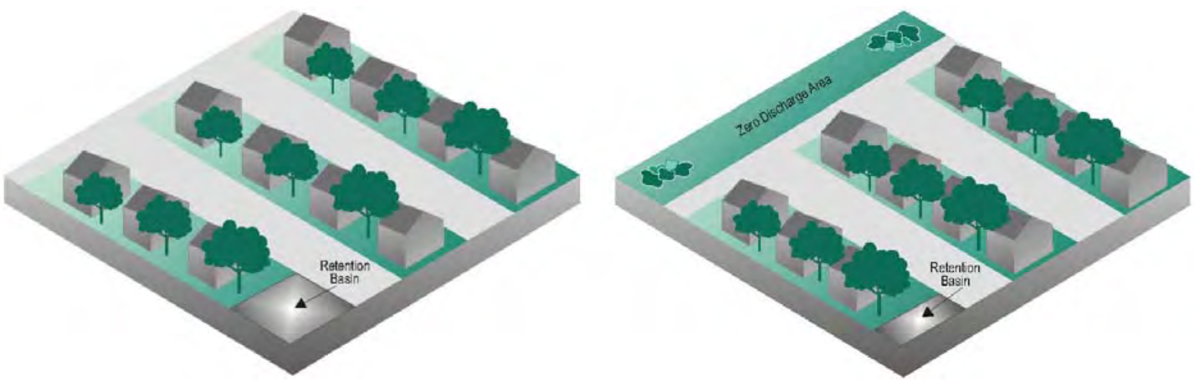
Figure 4-3: Schematic Drainage Plan for Site with a Self-Treating Area

4.2 Self-Retaining Areas

In "self-retaining areas" or "zero discharge areas," a portion of the amount of stormwater runoff that is required to be treated is infiltrated or retained in depressed landscaped areas. If it is possible to create a self-retaining area on your site, you can design smaller stormwater treatment measures (as illustrated in Figures 4-4 and 4-5). ***Drainage from roofs and paving is directed to the self-retaining area***, where it can pond and infiltrate into the soil. Self-retaining areas may be created by designing concave landscaped areas at a lower elevation than surrounding paved areas, such as walkways, driveways, sidewalks and plazas. The following design considerations apply to self-retaining areas:

- Self-retaining areas are designed as concave landscaped areas that are bermed or ditched to retain the first one-inch of rainfall without producing any runoff. Modeling conducted for the Harvest and Use, Infiltration and Evapotranspiration Feasibility/Infeasibility Criteria Report (Feasibility Report), prepared by BASMAA, demonstrated that a ponding depth of 3 inches is sufficient to meet the C.3 stormwater treatment objective.
- Runoff may enter the self-retaining area as sheet flow, or it may be piped from a roof or paved area. The elevation difference between the self-retaining area and adjacent areas should be sufficient to allow build-up of turf or mulch within the self-retaining area.

- A 2:1 ratio of impervious area to the receiving pervious area is acceptable. Modeling conducted for the Feasibility Report confirmed that a 2:1 ratio is sufficient to achieve the C.3.d stormwater treatment objective, even for soils with very low hydraulic conductivity.
- Drainage from self-retaining areas (for amounts of runoff greater than the first one-inch) must flow to off-site streets or storm drains without flowing onto paved areas within the site.
- If overflow drains or inlets to the storm drain system are installed within the self-retaining area, set them at an elevation of at least 3 inches above the low point to allow ponding. The overflow drain or storm drain inlet elevation should be high enough to allow ponding throughout the entire surface of the self-retaining area.
- Any pavement within the self-retaining area cannot exceed 5 percent of the total self-retaining area.
- Slopes may not exceed 4 percent.
- The municipality may require amended soils, vegetation and irrigation to maintain soil stability and permeability.
- Self-retaining areas shall be protected from construction traffic and compaction.



Conventional Design **Design with "Self-Retaining" or "Zero Discharge" Area**

Figure 4-4: Allowing some runoff from impervious surfaces to be retained and infiltrate in a "self-retaining" or "zero discharge" area can reduce the size of the required stormwater treatment measure. (Source: BASMAA 2003)

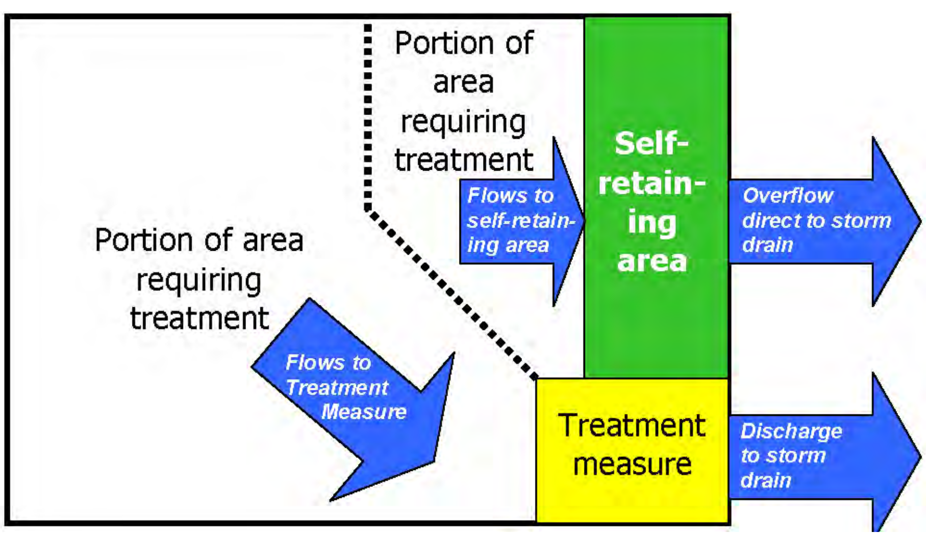


Figure 4-5: Schematic Drainage Plan for Site with a Self-Retaining Area

If you are considering using a self-retaining area in a project that must meet hydromodification management (HM) requirements, use the Bay Area Hydrology Model to identify the appropriate sizing of the self-retaining area to meet the HM objective of matching post-project stormwater flows and durations to pre-project patterns for smaller, frequent storms (ranging from 2- to 10-year storm events). See Chapter 7.

4.3 Reducing the Size of Impervious Areas

A variety of project features can be designed so that they result in a smaller "footprint" of impervious surface. These techniques generally need to be incorporated very early in the project design. A number of techniques for reducing impervious surfaces are described below.

Alternative Site Layout Techniques

Check with your local jurisdiction regarding its policies regarding the following site design measures:

- Use ***pervious pavement*** – such as porous concrete, porous asphalt, or unit block pavers – which are not considered "impervious" if designed to store and infiltrate the rainfall runoff volume described in Provision C.3.d of the MRP. See section 6.9 for pervious paving technical guidance.
- Reduce building footprints by using compact, ***multi-story structures,*** as allowed by local zoning regulations.
- ***Cluster buildings*** to reduce the length of streets and driveways, minimize land disturbance, and protect natural areas.
- *Design* ***narrow streets*** and driveways, as allowed by the local jurisdiction.
- *Use* ***sidewalks on only one side*** of the street may be appropriate in areas with little pedestrian and vehicular traffic, as allowed by the local jurisdiction.

Minimize Surface Parking Areas

A variety of techniques can be used to minimize surface parking areas, in terms of the number and size of parking spaces, as allowed by the local jurisdiction. These solutions focus on either reducing the demand for parking, maximizing the efficiency of parking utilization, or implementing design solutions to reduce the amount of impervious surface per parking space.

- Reduce parking demand by ***separating the cost of parking*** from the cost of housing or leasable space. This allows the buyer or tenant to choose how much parking they actually need and are willing to pay for.
- Maximize efficiency of parking utilization with ***shared parking*** that serves different land uses that have different times of peak demand. For example, an office use with demand peaks during the day can share parking with restaurants, where demand is greatest during the evening, and to some extent residential uses, where demand peaks are in the evenings, nights and on weekends.
- ***Structured parking*** can be an efficient way to reduce the amount of impervious surface needed for parking. Structured parking can be integrated with usable space in buildings

that also house office or residential space, or include ground-floor retail lining the street. Shared parking strategies can work very well with structured parking.

- ***Parking lifts*** are another way to reduce the amount of impervious surface needed for parking. A parking lift stacks two to three cars using a mechanical lift for each surface space. They can be operated manually by residents or employees, or by a valet or parking attendant. With proper training for residents, employers, or parking attendants, this strategy can be a practical way to double or triple the parking capacity given a set amount of land.

Figure 4-6: Parking Lifts in Parking Garage, Berkeley

- Another way to maximize the efficient use of parking area is ***valet parking***, where attendants park cars much closer and tighter than individual drivers would in the same amount of parking space.

4.4 Rainwater Harvesting and Use

Technical guidance for rainwater harvesting and use is provided in Section 6.10 of Chapter 6. A rainwater harvesting system is considered a stormwater treatment measure if it is designed to capture and use the full amount of rainwater runoff that is required to be treated per Provision C.3.d of the MRP. A rainwater harvesting system is considered a site design measure if it is designed to capture and use less than the C.3.d amount of runoff. If your project will include a rainwater harvesting system as a site design measure, follow the guidance in Section 6.10, with the exception of meeting the C.3.d stormwater treatment sizing criteria.

4.5 Tree Preservation and Planting and Interceptor Tree Credits

Trees perform a variety of functions that reduce runoff volumes and improve water quality. Leaf canopies intercept and hold rainwater on the leaf surface, preventing it from reaching the ground and becoming runoff. Root systems create voids in the soil that facilitate infiltration. Trees also absorb and transpire large quantities of groundwater, making the soil less saturated, which allows more stormwater to infiltrate. Through the absorption process, trees remove pollutants from stormwater and stabilize them. Finally, tree canopies shade and cool paved areas.

Consistent with the Feasibility Report submitted to the Water Board by BASMAA on April 29, 2011, a project may earn stormwater treatment credits by planting new trees and preserving existing trees at the project site. To be eligible for these credits, the trees need to meet the minimum requirements listed in Section 4.5.1. The system of interceptor tree credits is described in Table 4-1, and guidance for planting and protection during construction is provided in Section 4.5.2. Additional information about planting trees in dense, urban settings is provided in Section 4.5.3.

Table 4-1
Stormwater Treatment Credits for Interceptor Trees

	New Evergreen Trees	New Deciduous Trees	Existing Trees
Credits for new and existing trees that meet interceptor tree minimum requirements	200 square feet	100 square feet	Square footage under the tree canopy for: ▪ Trees with an average DBH* of less than 12 in. ▪ Trees with an average DBH of 12 inches or more.

Source: BASMAA Feasibility Report (which based its tree credit system on the tree credit system in the statewide Construction General Permit standards for post-construction stormwater control)

4.5.1 Minimum Requirements for Interceptor Trees

The following requirements are based on guidance in the Stormwater Quality Design Manual for the Sacramento and South Placer Regions.

PLANTING NEW INTERCEPTOR TREES

To be eligible for stormwater interceptor tree credits, trees planted as part of the project must meet the following minimum requirements:

- Plant tree within 25 feet of ground-level impervious surface;
- Maintain appropriate distance from infrastructure and other structures that could be damaged by roots; avoid overhead power lines, underground utilities, septic systems, sidewalks, curbs, patios, etc.
- Space trees so crowns do not overlap at 15 yrs of growth;
- Specified trees must be 15 gallon container minimum size at planting;
- Dwarf species are not acceptable; native species and trees with a large canopy at maturity are preferred.
- Clearly label on project plans the trees designated for stormwater interceptor tree credits.

PRESERVATION OF EXISTING INTERCEPTOR TREES

To be eligible for stormwater interceptor tree credits, existing trees preserved at the project site must meet the following minimum requirements:

- The tree trunk must be located within 25 feet of ground-level impervious surface that is included in the project's calculation of the amount of stormwater runoff that will require treatment.
- Dwarf species are ineligible.
- Clearly label on project plans the trees designated for stormwater interceptor tree credits.

4.5.2 Interceptor Tree Planting and Construction Guidelines

The following guidelines are based on guidance in the Stormwater Quality Design Manual for the Sacramento and South Placer Regions.

PLANTING NEW INTERCEPTOR TREES

- Drainage and soil type must support selected tree species.
- Avoid compaction of soil in planting areas.
- Avoid contamination of planting areas by construction related materials such as lime or limestone gravel.
- Install turf grass no closer than 24 inches from trunk;
- Add 4-6 inches deep of hardwood mulch, 6 inches away from trunk;
- Permanent irrigation system may be required;
- Avoid excess irrigation due to mosquito issues;
- Pruning and removal and replacement of diseased/damaged tree may be required.
- If construction is ongoing, install high-visibility protective fencing at the outer limit of the critical root zone area.

PLANTING NEW INTERCEPTOR TREES

- Plan new landscaping under existing trees to avoid grade changes and excess moisture in the trunk area, depending on the tree species. Preserve existing plants that are compatible with irrigation requirements and are consistent with the landscape design.
- Avoid grade changes greater than 6 inches within the critical root zone.
- Avoid soil compaction under trees.
- During construction minimize disruption of the root system.
- Plans and specifications shall clearly state protection procedures for interceptor trees to be preserved.
- Protect existing trees during construction through the use of high-visibility construction fencing at the outer limit of the critical root zone area. The fence must prevent equipment

traffic and storage under trees. Excavation in this area should be done by hand and roots ½-inch and larger should be preserved. Pruning of branches or roots should be done by, or under supervision of, an arborist.

- Provide irrigation of trees during and after construction.
- Install turf grass no closer than 24 inches of trunk.

4.5.3 Tree Planting in Dense, Urban Areas

When planting trees, particularly along streets where space is limited and roots may damage hard surfaces, ***consider the use of structural soils***. Structural soil is a planting medium that consists of a stone skeleton structure for strength and clay soil for water retention, which allows urban trees to grow under pavement. The structural soil system creates a load-bearing matrix with voids filled with soil and air, essential for tree health. This allows for greater tree growth, better overall heath of trees, and reduced pavement uplifting by tree roots. The voids that benefit the tree roots also provide increased stormwater storage capacity, allowing tree pits in paved areas to serve as a series of small detention basins. See www.hort.cornell.edu/uhi/outreach/csc/ for more information on structural soils. Before including structural soils in your project, please contact the municipality for information and requirements specific to the local jurisdiction.

Structural soils may allow the installation of ***large shade trees*** in narrow medians where the tree otherwise may conflict with infrastructure.

Load-bearing modular grid products, such as the Silva Cell, have also been developed to allow the planting of trees in uncompacted native soils, fill soils, or stormwater treatment soils, extending under sidewalks and other areas of pavement. With the Silva Cell product, for example, each cell is composed of a frame (or frames) and a deck (see Figure 4-7).

The frames can be stacked one, two, or three units high before they are topped with a deck to create a maximum amount of soil volume for tree root growth and stormwater infiltration. Cells can be installed laterally as wide as necessary. Void space within the cells may accommodate the surrounding utilities.

Figure 4-7: Silva Cells, stacked three units high. (Source: Deep Root Technologies, www.deeproot.com). The use of this photograph is for general information only, and is not an endorsement of this or any other proprietary product.

Chapter

5

General Technical Guidance for Treatment Measures

The technical guidance in this Chapter applies to all types of stormwater treatment measures.

This chapter contains general technical information regarding stormwater treatment measures for all types of new development and redevelopment projects. It includes the following topics:

- Hydraulic sizing criteria,
- The applicability of non-landscape based treatment measures,
- Guidance regarding "treatment trains,"
- Infiltration guidelines,
- Using underdrains,
- Using low-flow systems,
- Selecting and maintaining plantings in landscape-based treatment measures,
- Mosquito control requirements,
- Incorporating treatment with hydromodification management measures, and
- Getting water into stormwater treatment measures.

5.1 Hydraulic Sizing Criteria

The stormwater treatment measures must be sized to treat stormwater runoff from ***relatively small sized storms*** that comprise the vast majority of storms. The intent is to treat most of the stormwater runoff while recognizing that it would be infeasible to size stormwater treatment measures to treat runoff from very large storms that occur every few years. (See Section 5.6 for more information on how stormwater treatment measures that are sized to treat runoff from small, frequent storms can be designed to also handle flows from large, infrequent storms.)

How Much of Project Site Needs Stormwater Treatment?

The Municipal Regional Stormwater Permit requires that, for all "Regulated Projects"[1] the project site must receive stormwater treatment. Municipalities may require stormwater treatment for projects that are smaller than the Regulated Project threshold, and in these cases, stormwater treatment is required to the maximum extent practicable (MEP). Exceptions to the stormwater treatment requirement for Regulated Projects are pervious areas that are "self-treating" (including areas of pervious pavement with a hydraulically-sized aggregate base layer) as described in Section 4.1, and "self-retaining areas" designed to store and infiltrate runoff from rooftops or paved areas as described in Section 4.2. Other than "self-treating areas" and "self-retaining areas," ***ALL AREAS AT A PROJECT SITE*** must receive stormwater treatment.

Flow-Based Versus Volume-Based Treatment Measures

For hydraulic sizing purposes, stormwater treatment measures can be divided generally into three groups: flow-based, volume-based, and treatment measures that use a combination of flow and volume capacity. The ***flow-based treatment measures*** remove pollutants from a moving stream of stormwater, and the treatment measures are sized based on hourly or peak flow rates. Examples of flow-based treatment measures include vegetated buffer strips and media filters. The ***volume-based treatment measures*** detain stormwater for periods of between 24 hours and 5 days, so the sizing is based on detaining a large volume of water for treatment and/or infiltration to the ground. Examples of volume-based stormwater treatment measures include extended detention basins and infiltration trenches. Flow-through planters and bioretention areas can use a ***combination of flow and volume capacity*** for stormwater treatment. Table 5-1 shows which hydraulic sizing method is appropriate for commonly used stormwater treatment measures.

Table 5-1
Flow and Volume Based Treatment Measure Designs

Type of Treatment Measure	Type of Hydraulic Sizing Criteria to Use
Tree well filter	Flow-based
Vegetated buffer strip	Flow-based
Green roof	Flow-based
Media filter	Flow-based
Bioretention area	Flow-based or Combination flow and volume
Flow-through planter box	Flow-based or Combination flow and volume
Infiltration trench	Volume-based
Extended detention basin	Volume-based
Pervious paving	Volume-based

Volume-Based Sizing Criteria

The Municipal Regional Stormwater Permit specifies two alternative methods for hydraulically sizing volume-based stormwater treatment measures. One of the permit-approved methods,

[1] "Regulated Projects" are projects that create and/or replace 10,000 square feet or more of impervious surface. Beginning December 1, 2011, this threshold is reduced to 5,000 square feet of impervious surface for surface parking areas, restaurants, auto service facilities, and gasoline outlets.

the "Urban Runoff Quality Management Approach," is based on simplified procedures that are not recommended for use when information is available from continuous hydrologic simulation of runoff using local rainfall records (see "Urban Runoff Quality Management, WEF Manual of Practice No. 23/ASCE Manual and Report on Engineering Practice No. 87.) Because the results of continuous simulation modeling based on local rainfall are available, the Clean Water Program recommends the use of the "California Stormwater BMP Handbook Approach," or "80 percent capture method," ***shown in the text box.***

Please note that the Clean Water Program's member agencies may also allow project applicants to use an even ***simpler sizing method*** for sizing flow/volume-based treatment measures such as flow-through planters and bioretention areas, which is described below, under the heading, Simplified Sizing Methods.

The ***80 percent capture method*** should be used when sizing extended detention basins. The 80 percent runoff value is determined by the Storage, Treatment, Overflow, Runoff Model (STORM), which uses continuous simulation to convert rainfall to runoff based on local rainfall data. STORM was developed by the Hydrologic Engineering Center of the U.S. Army Corps of Engineers. (See http://www.hec.usace.army.mil/publications.)

Volume-Based Sizing Criteria

Volume-based treatment measures shall be designed to treat stormwater runoff equal to the volume of annual runoff required to achieve ***80 percent or more capture***, determined in accordance with the methodology set forth in Appendix D of the California Stormwater Best Management Practices Handbook (2003), using local rainfall data.

The 80 percent capture method is described in the California Stormwater Quality Association's 2003 Stormwater Best Management Practice Handbook New Development and Redevelopment available at www.cabmphandbooks.com. This method involves the following steps.

Figure 5-1: Water Quality Basin in Dublin (example of a volume-based treatment measure)

1. Determine the ***mean annual precipitation*** for the project site using the Mean Annual Precipitation Map of Alameda County (Appendix D). Use the Oakland Airport unit basin storage volume values from Table 5-2 if the project location's mean annual precipitation is 16.4 inches or greater and the San Jose values if it is less than 16.4 inches.

2. Determine the ***drainage area*** that will flow to the volume-based treatment measure. This includes all areas that will contribute runoff to the stormwater treatment measure, including

pervious areas, impervious areas, and off-site areas, regardless of whether they are directly or indirectly connected to the stormwater treatment measure. Any self-treating areas (described in Section 4.1) that discharge to the storm drain system without directing flows to the stormwater treatment measure are not included in the treatment measure drainage area.

Table 5-2
Unit Basin Storage Volumes in Inches for 80 Percent Capture Using 48-Hour Drawdowns

		Composite Runoff Coefficient for Area Tributary to the Volume-Based Treatment Measure			
Location	**Mean Annual Precipitation inches**	**0.25**	**0.50**	**0.75**	**1.00**
Oakland Airport	18.35	0.17 inches	0.34	0.50	0.67
San Jose	14.4	0.14	0.28	0.42	0.56
Source: CASQA 2003 .					

> A ***runoff coefficient*** is ratio of the runoff rate to rainfall and it is dimensionless. For example, a runoff coefficient of 0.70 means that seventy percent of the rainfall that falls on this type of surface will flow off as runoff.

3. Determine the ***composite runoff coefficient*** for the area at the project location that is tributary to the volume-based treatment system. The runoff coefficients for stormwater treatment are lower than for flood control. Runoff coefficient "C" factors from BASMAA include the estimated values shown in Table 5-3 for use in sizing stormwater treatment measures. These "C" factors are only appropriate for stormwater treatment designs that are based on ***small, frequent storms.*** "C" factors such as those in the Alameda County Hydrology and Hydraulics Manual must be used for flood control sizing. The composite runoff coefficient is calculated as a weighted average. Multiply the area of each type of surface tributary to a stormwater treatment measure by the respective runoff coefficient. Add the results and divide by the total area that drains to a stormwater treatment measure.

4. Use the composite runoff coefficient to interpolate a ***unit basin storage volume value*** for composite runoff coefficients that are different from the four (0.25, 0.50. 0.75, and 1.00) listed in Table 5-2. For example using the Oakland Airport values, if the composite runoff coefficient was calculated to be 0.55, the unit basin storage volume would be 0.37 inches. The 0.55 composite runoff coefficient is one-fifth of the way between the table's 0.5 and 0.75 composite runoff coefficient values.

5. In order to account for the difference between ***mean annual precipitation of the project site*** and the two rainfall locations shown, adjust the unit basin storage volume value by multiplying the unit basin storage volume value by the following factor:

$$\frac{\text{(project location mean annual precipitation)}}{\text{(18.35 or 14.4, as appropriate)}}$$

6. Calculate the ***required capture volume*** by multiplying the drainage area from step 2 by the adjusted unit basin storage volume value. Due to the mixed units that result, such as acre-inches, it is recommended that the resulting volume be converted to cubic feet for use during design.

Table 5-3
Estimated Runoff Coefficients for Various Surfaces During Small Storms

Type of Surface	Runoff Coefficients "C" factor
Roofs	0.90
Concrete, grouted pavers	0.80
Asphalt	0.70
Cobbles	0.30
Natural stone (without grout)	0.13
Pervious concrete	0.10
Pervious asphalt	0.10
Pervious concrete Brick (without grout)	0.10
Turf block	0.10
Unit pavers on sand	0.10
Crushed aggregate	0.10
Grass	0.10
Grass over porous plastic	0.05
Gravel over porous plastic	0.05

Note: These C-factors are only appropriate for small storm treatment design and should not be used for flood control sizing. When available, locally developed small storm C-factors for various surfaces may be used.

The runoff coefficients in Table 5-3 are for use only in stormwater treatment designs based on ***small, frequent storms***. Flood control sizing must be based on coefficients such as those in the Alameda County Hydrology and Hydraulics Manual.

The other critical issue for the design of volume-based stormwater treatment measures that temporarily pond water is the ***drawdown time***. The outlet structure's orifices should be designed to draw down the stormwater flow being treated no faster than 48 hours. Forty-eight hours drawdown time is the minimum acceptable drawdown time for stormwater treatment. A longer drawdown time is acceptable, up to a maximum of 5 days. Drawdown time may not exceed five days, to avoid creating conditions for mosquito breeding.

Flow-Based Sizing Criteria

The Municipal Regional Stormwater Permit specifies three alternative methods for hydraulically sizing flow-based stormwater treatment control measures, such as vegetated swales, flow through planter boxes, and media filters. These three methods are described in Table 5-4.

The Clean Water Program recommends the use of a ***rainfall of 0.2 inches/hour*** to design flow-based treatment systems.

Table 5-4
Flow-based Sizing Criteria Included in MRP Provision C.3.d

Flow-based Sizing Criteria	Description	Practice Tips
Percentile Rainfall Intensity	Ranks the hourly depth of rainfall from storms over a long period, determines the 85th percentile hourly rainfall depth, and multiplies this value by two.	This approach requires hydrologic studies that have not been conducted in Alameda County. Results of studies in other Bay Area locations showed a rainfall intensity of about 0.2 inch/hour.
0.2 Inch-per-Hour Intensity ***(Recommended Method)***	Simplification of the Percentile Rainfall Intensity Method. In the Bay Area, calculating the percentile rainfall intensity has generally resulted in a value of about 0.2 inches/hour.	This simplified approach is most commonly used.
10% of the 50-year peak flow rate ("Factored Flood Flow Approach")	Rainfall intensity is determined using Intensity-Duration-Frequency curves published by the local flood control agency or climactic data center.	This approach may be used if the 50-year peak flow has been determined. This approach has not been used locally.

The percentile rainfall intensity method is based on ranking the hourly depth of rainfall from storms over a long period, and determining the 85th percentile hourly rainfall depth and multiplying this value by two. In the Bay Area this value is generally around 0.2 inches/hour. The permit also allows the use of 0.2 inches/hour as one of the three alternative methods regardless of the results from calculating values from local rainfall depths.

Because two of the permit allowed methods yield similar results and the third method requires data that may not be readily available, the Clean Water Program recommends the use of a ***rainfall of 0.2 inches/hour*** to design flow-based treatment systems.

The amount of flow that the stormwater treatment measure must be sized to treat is calculated using the rational method:

$$Q = CiA$$

Where

Q = flow in ft^3/second

i = rainfall intensity in inches/hour

C = composite runoff coefficient (unitless – see Table 5.3)

A = drainage area in acres

To calculate the required treatment flow, simply multiply the ***drainage area*** that contributes flow to the treatment measure by the ***composite runoff coefficient*** by 0.2 inches/hour of rainfall intensity. The drainage area and composite runoff coefficient are determined by following steps 1 through 3 described above under the Volume-Based Sizing Criteria.

Appendix C includes an example (example 1) of sizing vegetated swales and bioretention areas using this sizing method.

As with volume-based treatment measures, the Clean Water Program's member agencies may allow project applicants to use ***simplified sizing methods*** for some flow-based treatment measures. This is described below, under the heading, "Simplified Sizing Methods."

Combination Flow and Volume Design Basis

Some stormwater treatment measures, such as bioretention areas and flow-through planters, include some design elements that provide flow-based treatment and some that provide volume-based treatment. For example, flow-based treatment occurs in a biotreatment area with an underdrain as stormwater filters through the soil and flows out the underdrain. Volume-based treatment is provided when stormwater is stored in the surface ponding area and the pore spaces of the soil media. The surface ponding area may be sized so that the ponding area functions to retain water prior to it entering the soil at the minimum 5 inches per hour required by MRP Provision C.3.c(2)(b)(vi).

The "simplified approach" for sizing bioretention areas and flow-through planters, in which the surface area of the treatment measure is designed to be 4 percent of the impervious area that drains to the treatment measure, is a flow-based sizing approach. This approach tends to result in the design of a conservatively large treatment measure because it does not account for any storage provided by the surface ponding area. A volume-based sizing approach for bioretention areas, in which the surface ponding area and depth are sized to contain the entire water quality design volume, is also conservative because it does not take into account the emptying of this ponding area into the soil media during the storm event.

Figure 5-2: Bioretention area, Emeryville (example of a combination flow- and volume-based treatment measure)

Provision C.3.d of the MRP specifies that treatment measures that use a combination of flow and volume capacity shall be sized to treat at least 80 percent of the total runoff over the life of the project, using local rainfall data. This sizing criteria is best applied when using a continuous simulation hydrologic model to demonstrate that a treatment system is in compliance with C.3.d. However, when doing sizing calculations by hand, compliance with C.3.d. can be demonstrated by showing how the treatment system design meets both the flow-based and volume-based criteria.

For bioretention areas and flow-through planters, the following approach may be used to take into consideration both the flow of stormwater through the planting media and the volume of stormwater in the surface ponding area. Note that the approach assumes that all of the design rainfall becomes runoff, and thus it is appropriate for use where the drainage area to the bioretention area is mostly impervious.

1. Determine the required treatment volume using the ***80 percent capture method*** described in Section 5.1. As part of this method, you will calculate the ***unit basin storage volume*** in inches using Table 5-2 (adjusted for the mean annual precipitation of the project site) and the ***required capture volume*** in cubic feet (the unit basin storage volume multiplied by the drainage area to the treatment measure, converted to units of cubic feet). For example, say you determined the adjusted unit basin storage volume to be 0.5 inches, and the drainage area to the bioretention facility is 7,000 square feet. Then the required capture volume would be 0.5 inches × (1 foot/12 inches) × 7,000 square feet = 292 cubic feet.

2. Assume that a ***rainfall intensity of 0.2 inches/hour*** will be used as the flow based sizing criteria (as recommended by the Clean Water Program).

3. Assume that the rain event that generates the required capture volume of runoff determined in Step 1 occurs at a constant intensity of 0.2 inches/hour from the start of the storm (i.e., assume a rectangular hydrograph). Calculate the ***duration of the rain event*** by dividing the unit basin storage volume by the intensity. In other words, determine the amount of time required for the unit basin storage volume to be achieved at a rate of 0.2 inches/hour. For example, if the unit basin storage volume is 0.5 inches, the rain event duration is 0.5 inches ÷ 0.2 inches/hour = 2.5 hours.

4. Make a ***preliminary estimate of the surface area*** of the bioretention facility by multiplying the area of impervious surface to be treated by a sizing factor of 0.04. For example, a drainage area of 7,000 square feet × 0.04 = 280 square feet of bioretention treatment area.

5. Assume a bioretention area that is about 25% smaller than the bioretention area calculated in Step 4. Using the example above, 280 – (0.25 × 280) = 210 square feet. ***Calculate the volume of runoff that filters through the treatment soil*** at a rate of 5 inches per hour (the design surface loading rate for bioretention facilities), for the duration of the rain event calculated in Step 3. For example, for a bioretention treatment area of 210 square feet, with an infiltration rate of 5 inches per hour for a duration of 2.5 hours, the volume of treated runoff = 210 square feet × 5 inches/hour × (1 foot/12 inches) × 2.5 hours = 219 cubic feet.

6. Calculate the portion of the required capture volume ***remaining after treatment is accomplished by filtering*** through the treatment soil. The result is the amount that must be stored in the ponding area above the reduced bioretention area assumed in Step 5. For example, the amount remaining to be stored comparing Step 1 and Step 5 is 292 cubic feet – 219 cubic feet = 73 cubic feet. If this volume is stored over a surface area of 210 square feet, the average ponding depth would be 73 cubic feet ÷210 square feet = 0.35 feet or 4.2 inches.

7. Check to see if the ***average ponding depth is between 6 and 12 inches***, which is the recommended allowance for ponding in a bioretention facility or flow-through planter. If the ponding depth is less than 6 inches, the bioretention design can be optimized with a smaller surface area (i.e., repeat Steps 5 and 6 with a smaller area). If the ponding depth is greater than 12 inches, a larger surface area will be required. (In the above example, the optimal size of the bioretention area is 190 square feet with a ponding depth of 6 inches.)

Appendix C includes examples of sizing bioretention areas using this combination flow- and volume-based method.

Simplified Sizing Methods

Some simplified sizing methods are offered to help evaluate, during the planning phase, whether sufficient land has been allocated for stormwater treatment. If these methods are used in place of design calculations for site-specific conditions, they may result in conservatively large stormwater treatment measures.

- A ***bioretention area*** or ***flow-through planter*** requires 4 percent of the impervious area (1,750 square feet of bioretention area per impervious acre). This is a flow-based ratio, based on runoff inflow resulting from 0.2 inches of rainfall per hour, with an infiltration rate of 5 inches per hour. This 4 percent "rule of thumb" does not take into consideration the volume of water that is temporarily detained in the surface ponding area.
- An ***extended detention basin*** has a minimum drainage area of 5 acres. Allow a 1-inch diameter outlet orifice for a 5-acre drainage area. Allow a 1-acre basin, 3.5-feet deep, for a 100-acre drainage area.

5.2 Applicability of Non-Low Impact Development (LID) Treatment

Beginning December 1, 2011, the MRP places ***restrictions on the use of non-LID treatment treatment measures.*** Only Special Projects will be allowed some limited use of non-LID treatment measures for stand-alone treatment of stormwater. Specifically, Special Projects, as defined in Appendix K, are allowed to treat specified percentages of the C.3.d amount of stormwater runoff with vault-based media filters that have a high flow rate and with tree well filters that have a high flow rate. See Appendix K for additional guidance on Special Projects.

> Effective December 1, 2011, there are restrictions on the use of non-LID treatment measures.

Underground vault-based, non-LID treatment measures typically require frequent maintenance to function properly, and experience has shown that because these systems tend to be "out of sight, out of mind," they often do not receive adequate maintenance. Where underground vaults are allowed, they must be sealed to prevent mosquito access and include suitable access doors and hatches to allow for frequent inspections and maintenance. But even when maintained properly, some types of underground vault systems lack the detention time required to remove ***pollutants associated with fine particles.*** See Appendix E for more information regarding inlet filters, oil/water separators, hydrodynamic separators and media filters.

5.3 Using Treatment Trains

Stormwater can be directed to flow through a series of different types of stormwater treatment measures that are each designed to treat different broad categories of stormwater pollutants. These groupings of stormwater treatment measures have been called "stormwater treatment trains" or a "multiple treatment system." The definition of treatment train given in Fact Sheet TC-60 of the CASQA Handbook is shown in the text box. The use of a ***series of treatment measures*** is most effective where each treatment measure optimizes the removal of a particular type of pollutant, such as coarse solids and debris, pollutants associated with fine solids, and dissolved pollutants. Stormwater treatment measures operate by using physical processes, such as sedimentation and filtration, to remove solids suspended in stormwater runoff. The removal of dissolved pollutants requires chemical adsorption or biological uptake. ***Each stormwater treatment measure in a treatment train should be sized using the Provision C.3 numeric sizing criteria.***

> ***What Is A Treatment Train?***
> A treatment train is a multiple treatment system that uses two or more stormwater treatment measures in series, for example, a settling basin/ infiltration trench combination.

The ***simplest version*** of a treatment train consists of pretreatment prior to the stormwater reaching the main treatment system. For example, bioretention areas may use vegetated buffer strips to pretreat stormwater to settle out sediment before the stormwater enters the

Figure 5-3: Tule Pond, Fremont

bioretention area. This type of pretreatment helps prevent sediment from clogging the bioretention area, which maximizes its life. Another example of a coupled ***pretreatment and treatment system*** is used in extended detention basins that have a small, sediment forebay where most of the larger sediment settles and can be easily removed.

The combining of ***three or more stormwater treatment measures*** in series is often limited in practice because of the expense and additional space required. Some prototypes exist, such as the Tule Pond at Tyson Lagoon in Fremont. This stormwater treatment system was constructed in 1998 by the Alameda County Flood Control and Water Conservation District. It includes a wet pond where most of the sediment in the incoming stormwater settles. The wet pond also includes log booms to trap floating debris. From the wet pond the water flows into two other treatment ponds that are shallower in depth and where finer sediments and their associated pollutants settle and dissolved pollutants are removed by aquatic vegetation. The entire system also allows infiltration of the stormwater into the underlying soils.

5.4 Infiltration Guidelines

Infiltration is prioritized by the MRP, and it can be a very cost-effective method to manage stormwater – if the conditions on your site allow. A wide-range of site-design measures and stormwater treatment measures can be used to increase stormwater infiltration and can be categorized as follows:

- ***Site design measures*** -- such as clustering development or otherwise laying out the site to reduce impervious area, routing drainage from building roofs to landscaped areas, and using pervious pavement.
- ***Indirect infiltration*** methods, which allow stormwater runoff to percolate ***into surface soils***. Runoff may reach groundwater indirectly, or it may be underdrained into subsurface pipes. Bioretention are examples of indirect infiltration methods. Unless geotechnical considerations preclude it, all projects should maximize infiltration of stormwater runoff through methods such as raising the underdrain in unlined bioretention areas (see Section 6.1).
- ***Direct infiltration*** methods***,*** which are designed to ***bypass surface soils*** and transmit runoff directly to subsurface soils, which allows infiltration to groundwater. These types of devices must be located and designed to limit the potential for stormwater pollutants to reach groundwater. Infiltration trenches are an example of a direct infiltration method.

The local jurisdiction may require a geotechnical review for your project. When selecting site design and stormwater treatment measures that promote on-site infiltration, be sure to ***follow the geotechnical engineer's recommendations*** based on soil boring data, drainage pattern, and the current requirements for stormwater treatment. The geotechnical engineer's input will be critical to prevent infiltrating water from damaging surrounding properties, public improvements, slope banks, and even mudslides from accumulated below-ground water.

Appendix J provides instructions for determining the feasibility and infeasibility of treating the entire C.3.d amount of runoff from a project with infiltration. ***Appendix F*** provides additional information to help you determine whether your project site is suitable for using site design and/or stormwater treatment measures that increase stormwater infiltration. Appendix F also describes regulatory requirements that apply to direct infiltration methods, as well as practical tips for design and construction.

5.5 Underdrains in Biotreatment Measures

Where the existing soils have a lower infiltration rate than soils specified for a landscaped-based stormwater treatment measure, or “biotreatment measure,” it may be necessary to install an underdrain to allow the treatment measure to function as designed and ***prevent the accumulation of standing water.*** Beginning December 1, 2011, the full amount of stormwater runoff specified in Provision C.3.d of the MRP will need to be infiltrated, evapotranspired, or harvested for use. Where this is infeasible, as determined using feasibility/infeasibility criteria included in Appendix J, stormwater biotreatment will be allowed. For projects subject to the requirements that go into effect on December 1, 2011, any use of underdrains will need to be consistent with the feasibility/infeasibility criteria, and/or any technical guidance for specific stormwater treatment measures in Chapter 6, which may be revised to show how underdrains may be incorporated in stormwater treatment measures that are designed to infiltrate and evapotranspire the C.3.d amount of runoff.

Underdrains are perforated to allow water to enter the pipe and flow to the storm drain system. To help prevent clogging, two rows of perforation may be used. Cleanouts should be installed to allow access to underdrains to remove clogs. ***Underdrains should NOT be wrapped in filter fabric,*** to help avoid clogging. Underdrains are typically installed in a layer of washed drain rock or Class 2 perm aggregate, beneath high-percolation stormwater biotreatment soils.

5.6 Technical Guidance for Low-Flow Systems

Although stormwater treatment measures are sized to remove pollutants from flows resulting from frequent, small storms, projects must be designed to handle flows for stormwater treatment and drainage from large infrequent flows to ***prevent flooding***. The integration of flood control and stormwater treatment may be accomplished in one of two ways, which are described below.

One option is to have the flows that are larger than those required by the hydraulic sizing criteria (given in Section 5.1) handled ***within the stormwater treatment measure.*** This includes making sure that treatment measures do not re-suspend and flush out pollutants that have been accumulating during small storms, and that stormwater treatment measures do not erode during flows that will be experienced during larger storms. Most vegetated buffer strips and extended detention basins are designed to handle flood flows, although they would not be providing much treatment during these flows. The technical guidance in Chapter 6 for treatment measures that operate in this manner includes design standards to accommodate flood flows associated with larger storms.

Bioretention areas, flow-through planter boxes, and other treatment systems that rely on filtering or infiltrating stormwater through soils must have ***overflow systems*** that allow flood flows larger than the increment of flow that can be treated to bypass the stormwater treatment measure. These systems have to include an alternative flow path for high flows, otherwise stormwater would back up and flood the project area. The technical guidance in Chapter 6 for treatment measures that operate in this manner includes design standards for high-flow bypasses.

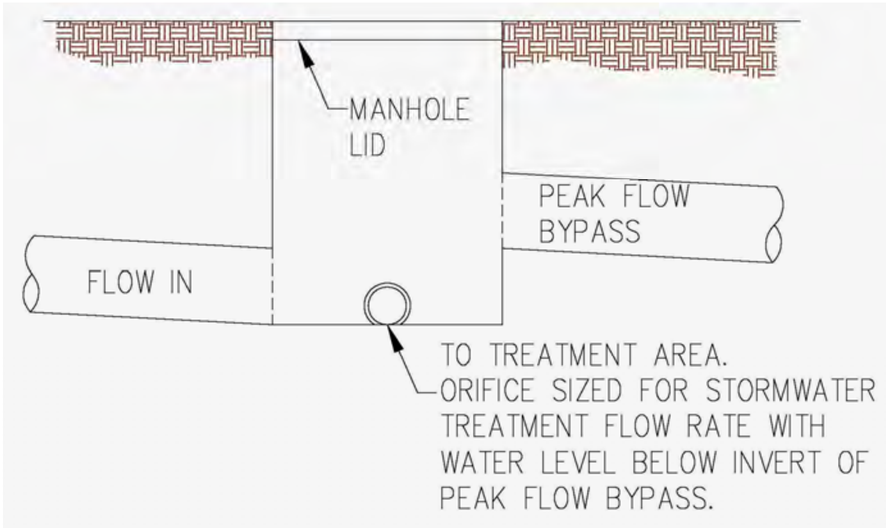


Figure 5-4: Stepped manhole design directs low-flows to treatment measure and diverts high flows to storm drain system. (BKF Engineers)

For some types of stormwater treatment measures that are designed as low-flow systems, it is often necessary to restrict stormwater flows and ***bypass the flows around the facility.*** In these instances the stormwater treatment measures are designed to treat only the water from small storm events, and may include infiltration trenches, media filters, or extended detention basins. Bypassing larger flows helps prevent hydraulic overload and resuspension of sediment, and it can protect stormwater treatment measures from erosion.

Flow splitter devices may be used to direct the initial flows of runoff, or "first flush," into a stormwater treatment measure, and bypass excess flows from larger storm events around the facility into a bypass pipe or channel. The bypass may connect directly to the storm drain system, or to another stormwater treatment measure that designed to handle high flows. This can be accomplished using a stepped manhole (Figure 5-4) or a proprietary flow splitter. As illustrated in Figure 5-5, runoff enters the device by way of the inlet at the left side of the figure; low flows are conveyed to the stormwater treatment measure by way of the outlet pipe at the lower right. Once the treatment measure reaches its design

Figure 5-5: StormGate™ flow splitter structure. Source: Contech Construction Products Inc. Use of this illustration is for general information only and is not an endorsement of this or any other proprietary device.

capacity, water backs up in the low-flow outlet pipe and into the flow splitter. When the water level in the flow splitter reaches the bypass elevation, stormwater begins to flow out the overflow pipe, shown at the upper right of the figure, bypassing the stormwater treatment measure. The bypass generally functions by means of a weir inside the flow splitter device.

5.7 Plant Selection and Maintenance

Selecting the appropriate plants and using sustainable, horticulturally sound landscape design and maintenance practices are essential components of a successful landscape-based stormwater treatment measure.

Plant Selection Guidance

Plant selection must consider the type of development and location, uses on the site and an appropriate design aesthetic. Ideally, a Landscape Architect will be involved as an active member of the design team ***early in the site design phase*** to review proposed stormwater measures and coordinate development of an integrated solution that responds to all of the various site goals and constraints. In some cases, one professional will design a stormwater control, while another designs the rest of the landscaping. In these situations it is critical for the professionals to work together very early in the process to integrate their designs. Appendix B provides user-friendly guidance in selecting planting appropriate to the landscape-based stormwater treatment measures included in Chapter 6.

Bay Friendly Landscaping

Bay-friendly landscaping is a whole systems approach to the ***design, construction and maintenance*** of the landscape in order to support the integrity of the San Francisco Bay watershed. Project sponsors are encouraged to use landscape professionals who are familiar with and committed to implementing Bay-Friendly landscaping practices from the initial plant selection through the long-term maintenance of the site. Appendix B summarizes Bay Friendly Landscaping Practices that may be implemented to benefit water quality of the Bay and its tributaries, based on the Bay-Friendly Landscaping Guidelines prepared by Stopwaste.Org (available at www.bayfriendly.org).

Integrated Pest Management

Integrated pest management (IPM) is a holistic approach to mitigating insects, plant diseases, weeds, and other pests. Projects that require a landscaping plan as part of a development project application are encouraged to use IPM, as indicated in each agency's source control measures list. ***Avoiding pesticides and quick release synthetic fertilizers*** is particularly important when maintaining stormwater treatment measures to protect water quality.

IPM encourages the use of many strategies for first preventing, and then controlling, but not eliminating, pests. It places a priority on fostering a healthy environment in which plants have the strength to resist diseases and insect infestations, and out-compete weeds. Using IPM requires an understanding of the life cycles of pests and beneficial organisms, as well as regular monitoring of their populations. When pest problems are identified, IPM considers all viable solutions and uses a combination of strategies to control pests, rather than relying on pesticides alone. The least toxic pesticides are used only as a last resort. More information on IPM is included in Appendix B.

Wetland Regulations and Treatment Measures

The Water Board's "Policy on the Use of Constructed Wetlands for Urban Runoff Pollution Control" (Resolution No. 94-102) recognizes that stormwater treatment wetlands that are constructed and operated pursuant to Resolution 94-102 and are constructed outside a creek or other receiving water are stormwater treatment systems, and, as such, properly maintained stormwater treatment measures are not waters of the United States subject to Sections 401 and 404 of the federal Clean Water Act.

Water Efficient Landscaping Requirements

The California Water Conservation in Landscaping Act of 2006 requires municipalities to adopt, by January 1, 2010, landscape water conservation ordinances that are at least as effective in conserving water as the Model Water Efficient Landscape Ordinance prepared by the Department of Water Resources. The Model Ordinance automatically went into effect, on January 1, 2010, in municipalities that had not adopted a comparable local ordinance.

Public landscapes and private developments including developer installed single family and multi-family residential landscapes with at least 2,500 square feet of landscape area are subject to the Model Ordinance. Homeowner provided landscaping at single family and multi-family homes are subject to the Model Ordinance if the landscape area is at least 5,000 square feet. Contact the municipality to ***determine whether your project is subject to the Model Ordinance*** or other water efficient landscaping ordinance.

5.8 Mosquito Control

Some types of stormwater treatment measures are designed to include standing water, and even treatment measures that are designed to eliminate standing water between storms may have the potential to ***retain standing water*** if they are not properly designed, constructed and maintained.

> Treatment measure designs and maintenance plans must include mosquito control ***design and maintenance strategies*** included in Appendix G.

To reduce the potential for stormwater treatment measures to lead to mosquito problems, the Clean Water Program developed a Vector Control Plan, which describes the need to include physical access for mosquito control staff to monitor and treat mosquitoes, and includes guidance for designing and maintaining stormwater treatment measures to control mosquitoes. The Alameda County Mosquito Abatement District (ACMAD) staff has identified a ***five-day maximum*** allowable water retention time, based on actual incubation periods of mosquito species in this area. With the exception of certain stormwater treatment measures designed to hold permanent water (e.g., CDS units and wet ponds), all treatment measures should drain completely within five days to effectively suppress vector production. *Please note that the design of stormwater treatment measures* ***does not require*** *that water be standing for five days. During five days after a rain event, standing water is allowable but not required for the stormwater treatment measure to function effectively.* Treatment measure designs and maintenance plans must include mosquito control ***design and maintenance strategies*** from the Vector Control Plan, included in Appendix G.

5.9 Incorporating Treatment and HM

In addition to requiring stormwater treatment, the MRP also requires that stormwater runoff be detained and released in a way that ***prevents increased creek channel erosion*** and siltation in susceptible areas. The amount of stormwater flow and the duration of flows that cause erosion must be limited to match what occurred prior to the proposed development or re-development. These hydromodification management (HM) requirements apply to projects that create one acre or more of impervious surface in most areas of Alameda County. The requirements do not apply to projects that drain directly to the bay or tidal channels nor to projects where stormwater flows into channel segments that have been hardened on three sides and/or are culverted continuously downstream to their outfall in a tidal area.

The HM requirements have been in effect since 2007 and are different from stormwater treatment, low impact development, and flood control requirements. To prevent hydromodification, Flow Duration Control facilities are ***designed for a range of 10 percent of the two-year up to the ten-year storm.*** This is different from the sizing criteria that are used for stormwater treatment and LID measures, and it is different from the design criteria used for flood control facilities. Depending on the project, it may be possible to meet the HM requirements and stormwater treatment requirements in one facility, as shown in Figure 5-6.
To help applicants meet the HM requirements, the Clean Water Program developed a Bay Area Hydrology Model (BAHM) with assistance from the municipal stormwater programs in Santa Clara and San Mateo Counties.

Figure 5-6: Detention pond in Pleasanton provides stormwater treatment and HM.

You can use the BAHM to ***automatically size*** *stormwater detention measures* **such as detention vaults, tanks, basins and ponds for Flow Dura**tion Control of post-project runoff (go to www.bayareahydrologymodel.org to download the BAHM). The BAHM also checks the facilities for performance as volume-based stormwater treatment measures, to meet the permit requirements for both stormwater treatment and HM. Chapter 7 gives more detail on HM requirements and the BAHM.

5.10 Getting Water into Treatment Measures

Stormwater may be routed into stormwater treatment measures using ***sheet flow or curb cuts.*** The following pages from the San Mateo County Sustainable Green Streets and Parking Lots Design Guidebook show common curb cut types. An 18-inch width is recommended for curb cuts, to avoid clogging. To avoid erosion, cobbles or other energy dissipater is recommended. A minimum two-inch drop in grade between the impervious surface and the finish grade of the stormwater treatment facility is recommended. This drop in grade needs to take into consideration the height of any vegetation.

Figure 5-7: Cobbles are placed at the inlet to this stormwater treatment measure in Fremont, to help prevent erosion.

Standard Curb Cut: Design Guidance

- Opening should be at least 18 inches wide; for smaller facilities 12" width may be allowed subject to municipal approval.
- Curb cut can have vertical sides or have chamfered sides at 45 degrees (as shown).
- Works well with relatively shallow stormwater facilities that do not have steep side slope conditions.
- Need to slope the bottom of the concrete curb toward the stormwater facility.
- Allow a change in elevation of 4 to 6 inches between the paved surface and biotreatment soil elevation, so that vegetation or mulch build-up does not obstruct flow.
- Provide cobbles or other energy dissipater to prevent erosion.

Figure 5-8: This standard curb cut at parking lot rain garden has 45 degree chamfered sides.

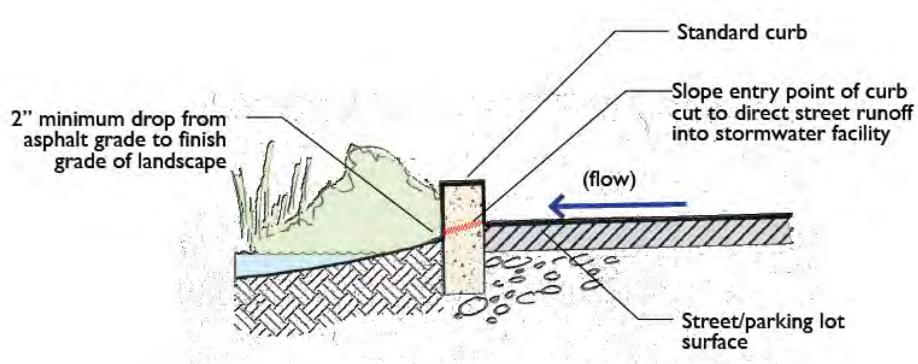


Figure 5-9: Standard curb cut: section view (Source: San Mateo Countywide Water Pollution Prevention Program [SMCWPPP] 2009)

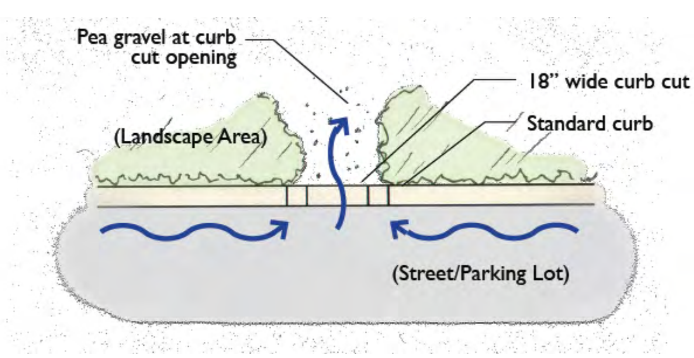


Figure 5-10: Standard curb cut: plan view (Source: SMCWPPP 2009)

Standard Curb Cut with Side Wings: Design Guidance

- Opening should be at least 18 inches wide; for smaller facilities 12” width may be allowed subject to municipal approval.
- Works well with stormwater facilities that have steeper side slope conditions.
- Need to slope the bottom of the concrete curb toward the stormwater facility.
- Allow a change in elevation of 4 to 6 inches between the paved surface and biotreatment soil elevation, so that vegetation or mulch build-up does not obstruct flow .
- Provide cobbles or other energy dissipater to prevent erosion.

Figure 5-11: The side wings of this standard curb cut help retain the side slope grade on each side of the curb cut opening.

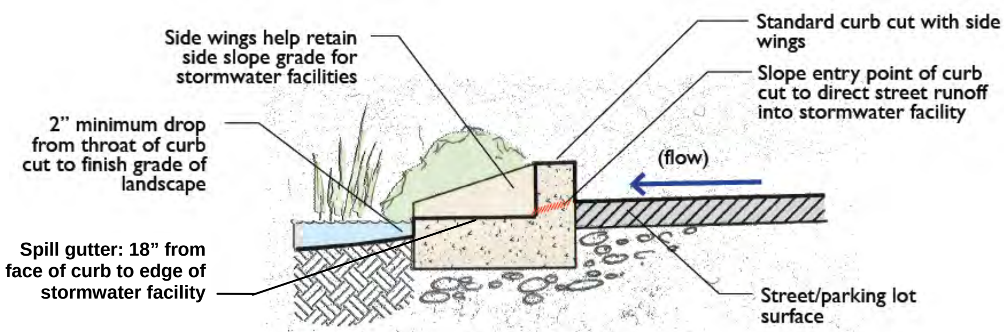


Figure 5-12: Standard curb cut with side wings: cut section view (Source: SMCWPPP 2009)

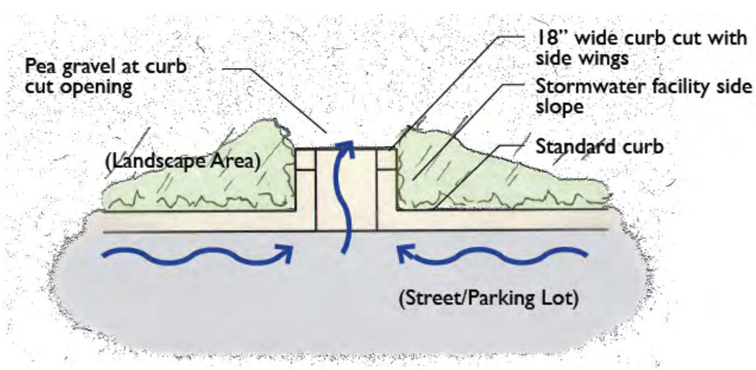


Figure 5-13: Standard curb cut with side wings: plan view (Source: SMCWPPP 2009)

Wheelstop Curbs: Design Guidance

- Wheelstops allow water to flow through frequently spaced openings.
- Wheelstops are most common in parking lot applications, but they may also be applied to certain street conditions.
- Need to provide a minimum of 6 inches of space between the wheelstop edge and edge of paving. This is to provide structural support for the wheelstop.
- Allow a change in elevation of 4 to 6 inches between the paved surface and biotreatment soil elevation, so that vegetation or mulch build-up does not obstruct flow .
- Provide cobbles or other energy dissipater at the wheel stop opening to prevent erosion.

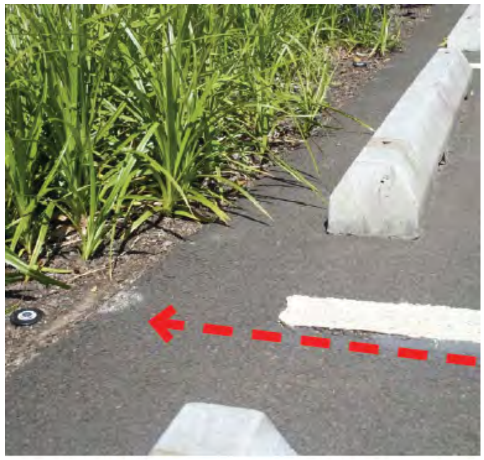


Figure 5-14: Stormwater runoff enters the stormwater facility through the 3-foot space between these wheelstops. The design could be improved by providing more of a drop in grade between the asphalt and landscape area.

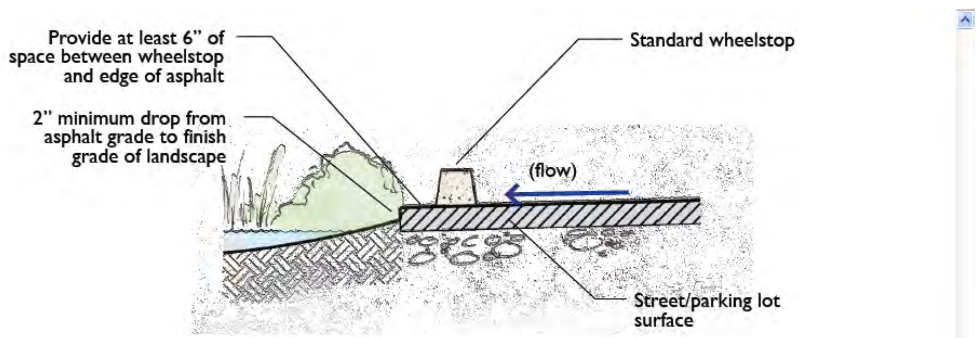


Figure 5-15: Opening between wheelstop curbs: section view (Source: SMCWPPP 2009)

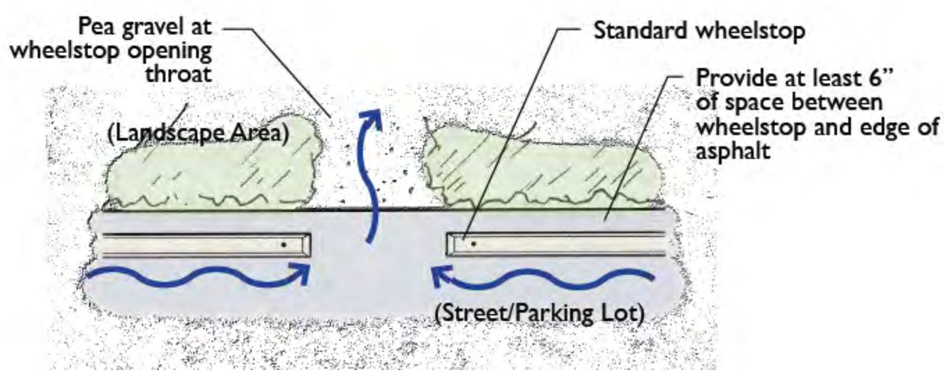


Figure 5-16: Opening between wheelstop curbs: plan view (Source: SMCWPPP 2009)

Grated Curb Cut: Design Guidance

- Grated curb cuts allow stormwater to be conveyed under a pedestrian walkway. The curb cut opening should be at least 18 inches wide; 12" may be allowed for smaller facilities subject to municipal approval.
- Grates need to be ADA compliant and have sufficient slip resistance.
- A 1-to-2 inch high asphalt or concrete berm should be placed on the downstream side of the curb cut to help direct runoff into the curb cut.
- Allow a change in elevation of 4 to 6 inches between the paved surface and biotreatment soil elevation, so that vegetation or mulch build-up does not obstruct flow.

Figure 5-17: A grated curb cut allows stormwater to pass under a pedestrian egress zone to the stormwater facility.

- Alameda County Standard Detail 513 may also be used as another sidewalk drain option (see Figure 5-20).

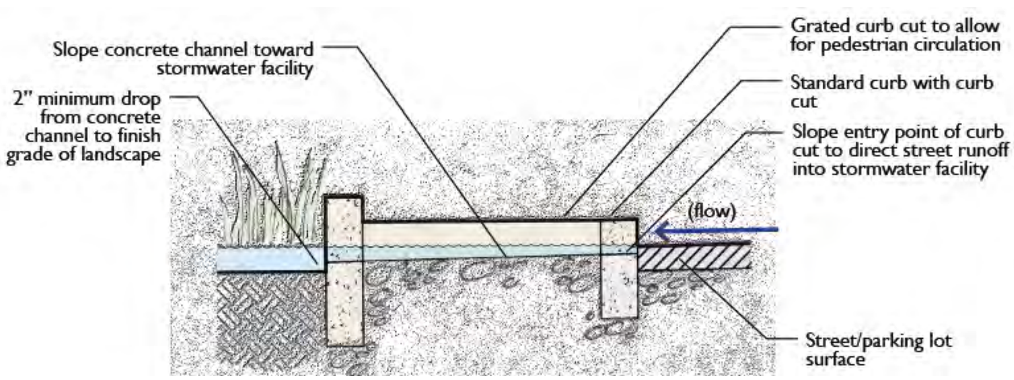


Figure 5-18: Grated curb cut: section view (Source: SMCWPPP 2009)

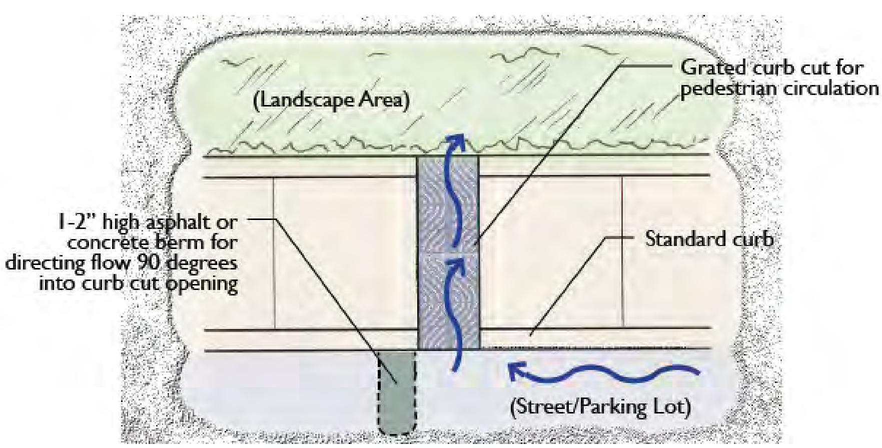


Figure 5-19: Grated curb cut: plan view (Source: SMCWPPP 2009)

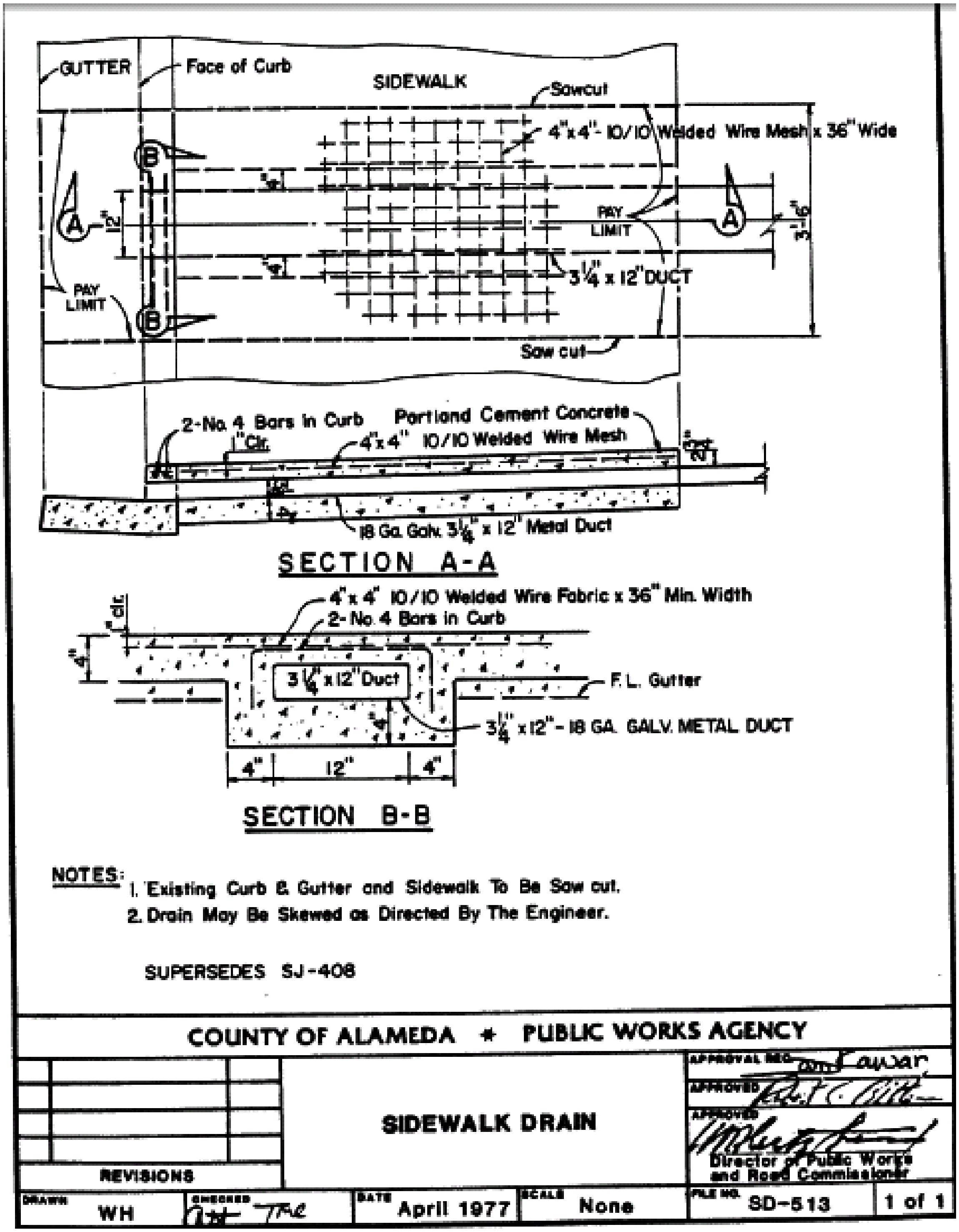


Figure 5-20: Alameda County Standard Detail 513, Sidewalk drain. This design may be used, as an alternative to plans shown in figures 5-19 and 5-20, to drain water from street gutter, across sidewalk, to stormwater treatment facility.

Chapter

6

Technical Guidance for Specific Treatment Measures

Technical guidance is provided for stormwater treatment measures commonly used in Alameda County.

Technical guidance is provided for the stormwater treatment measures listed in Table 6-1.

Table 6-1: Stormwater Measures for which Technical Guidance is Provided

Treatment Measures	**Section**
Bioretention[1] area/Rain garden	6.1
Flow-through planter	6.2
Tree well filter	6.3
Vegetated buffer strip	6.4
Infiltration trench	6.5
Extended detention basin	6.6
Pervious paving	6.7
Turf block and permeable joint unit pavers	6.8
Green roof	6.9
Rainwater harvesting and use	6.10
Media filter	6.11

Guidance in this chapter is intended to assist you in preparing project permit application submittals. Municipalities will require permit applications to include more specific drawings to address project site conditions, materials, plumbing connections, etc. This technical guidance was prepared using best engineering judgment and based on a review of various regional documents. Input from Water Board staff was incorporated where available. The Clean Water Program looks forward to working with Water Board staff to continue to improve this guidance.

[1] A bioretention area that is unlined and has a raised underdrain in the underlying rock layer to promote infiltration, as shown in Section 6.1, may also be called a "bioinfiltration area".

6.1 Bioretention Area

Figure 6-1: Bioretention area, Fremont

Best uses

- Any type of development
- Drainage area up to 2 acres
- Landscape design element

Advantages

- Detains low flows
- Landscape feature
- Low maintenance
- Reliable once established

Limitations

- Not appropriate where soil is unstable
- Requires irrigation
- Susceptible to clogging – especially if installed prior to construction site soil stabilization.

Bioretention[1] areas, or "rain gardens," function as soil and plant-based filtration devices that remove pollutants through a variety of physical, biological, and chemical treatment processes. These facilities normally consist of a ponding area, organic layer or mulch layer, planting soil, and plants. Bioretention areas are designed to distribute stormwater runoff evenly along a ponding area. Percolation of stored water in the bioretention area's engineered planting soil with a high rate of infiltration will enter an underlying rock layer, from which water will either percolate into the underlying soil or enter the underdrain, so that the bioretention area empties over two days. Unless the geotechnical engineer identifies conditions, such as steep slope or a high groundwater table, that would make infiltration unsafe, bioretention areas should be designed to maximize infiltration by raising the underdrain toward the top of the rock layer. Bioretention areas can be any shape, including a linear treatment measure. The guidelines listed below apply to bioretention areas.

Design and Sizing Guidelines

DRAINAGE AREA AND SETBACK REQUIREMENTS

- Set back from structures 10' or as required by structural or geotechnical engineer, or local jurisdiction.
- Area draining to the bioretention area does not exceed 2 acres.
- Area draining to the bioretention area shall not contain a significant source of soil erosion, such as high velocity flows along slopes not stabilized with vegetation or hardscape.

[1] A bioretention area that is unlined and has a raised underdrain in the underlying rock layer to promote infiltration may also be called a "bioinfiltration area".

- Areas immediately adjacent to bioretention area shall have slopes more than 0.5% for pavement and more than 1% for vegetated areas.
- Bioretention areas, including linear treatment measures, shall not be constructed in slopes greater than 4%, unless constructed as a series of bioretention cells. Separate bioretention cells by check dams up to 24 inches high and at least 25 feet apart. The slope within cells shall not exceed 4%. Bioretention cells are not recommended if overall slope exceeds 8%.
- If treatment measure is designed to infiltrate stormwater to underlying soils, a 50-foot setback is needed from septic system leach field.

TREATMENT DIMENSIONS AND SIZING

- Bioretention area may be sized to 4% of the impervious surface area on the project site. The area of impervious surface multiplied by 0.04 sizing factor will equal the footprint of the bioretention area. Alternatively, bioretention sizing may be calculated using the flow-based treatment standard, or the combination flow- and volume-based treatment standard described in Section 5.1 based on the flow entering the basin at the treatment flow rate over the initial hours of the storm until the treatment volume is attained.
- The bioretention area shall be sized to either:
  - Percolate the design treatment flow using a rate of 5 inches per hour. No additional allowance is provided for storage or for infiltration rates exceeding 5 inches/ hour; or,
  - Store the 24-hour treatment volume based on inflow at the water treatment rate for the initial hours of the storm and outflow by infiltration.
- Where there is a positive surface overflow, bioretention areas shall have freeboard of at least 0.2 feet to the lowest structural member versus the 100-year storm water level in the bioretention area, unless local jurisdiction has other requirements.
- Where the bioretention area is in a sump that depends on outflow through a catch basin, the bioretention area shall have a freeboard of at least 0.5 feet to the lowest building finished floor elevation (including garage and excluding crawl space) for conditions with the outlet 50 percent clogged, unless local jurisdiction has other requirements. Where the freeboard cannot be provided, emergency pump may be allowed on a case-by-case basis.
- Minimum 2 inches between the crest of the emergency outfall riser and higher elevation (top of planting mounds) of the treatment surface area.
- The elevation of the surface area may vary as needed to distribute stormwater flows throughout the surface area.
- Side slopes do not exceed 3:1; downstream slope for overflow shall not exceed 3:1.
- Surface ponding depths should vary, with a maximum 12-inch depth. If ponding depths exceed 6 inches, landscape architect shall approve planting palette for desired depth.
- The inlet to the overflow catch basin shall be at least 6 inches above the low point of the bioretention planting area.

INLETS TO TREATMENT MEASURE

Flow may enter the treatment measure (see example drawings in Section 5.10):

- As overland flow from landscaping (no special requirements)
- As overland flow from pavement (cutoff wall required)
- Through a curb opening (minimum 18 inches)
- Through a curb drain
- With drop structure through a stepped manhole (refer to Figure 5-3 in Chapter 5)
- Through a bubble-up manhole or storm drain emitter
- Through roof leader or other conveyance from building roof

- Where flows enter the biotreatment measure, allow a change in elevation of 4 to 6 inches between the paved surface and biotreatment soil elevation, so that vegetation or mulch build-up does not obstruct flow.
- Cobbles or rocks shall be installed to dissipate flow energy where runoff enters the treatment measure.

VEGETATION

- Plant species should be suitable to well-drained soil and occasional inundation. See planting guidance in Appendix B.
- Shrubs and small trees shall be placed to anchor the bioretention area cover.
- Tree planting shall be as required by the municipality. If larger trees are selected, plant them at the periphery of bioretention area.
- Underdrain trench shall be offset at edge of tree planting zone, as needed, to maximize distance between tree roots and underdrain. No trees shall be planted within 20 feet of overflow inlet. Underdrain shall be solid pipe 10 feet upstream and downstream of any tree.
- Use integrated pest management (IPM) principles in the landscape design to help avoid or minimize any use of synthetic pesticides and quick-release fertilizer. Check with the local jurisdiction for any local policies regarding the use of pesticides and fertilizers.
- Drought tolerant plants are preferred. Provide sufficient irrigation to maintain plant life.
- Trees and vegetation do not block inflow, create traffic or safety issues, or obstruct utilities.

SOIL CONSIDERATIONS SPECIFIC TO BIORETENTION AREAS

- Planting soil shall have a minimum percolation rate of 5 inches per hour and a maximum percolation rate of 10 inches/hour. Soil specifications are provided in Appendix L. Check with municipality for any additional requirements.
- Bioretention areas shall have a minimum planting soil depth of 18 inches.
- Provide 3-inch layer of mulch in areas between plantings.
- An underdrain system is generally required. Depending on the infiltration rate of in situ soils, the local jurisdiction may allow installation without an underdrain on a case-by-case basis.
- Underdrain trench shall include a 12-inch thick layer of Caltrans Standard Section 68-1.025 permeable material Class 2. A minimum 4-inch diameter perforated pipe shall be placed within the backfill layer. To help prevent clogging, two rows of perforation may be used.
- If there is at least a 10-foot separation between the base of the underdrain and the groundwater table, and geotechnical conditions allow, there shall be at least 6-inch separation between the perforated pipe and the base of the trench to allow percolation.

SOIL CONSIDERATIONS FOR ALL BIOTREATMENT SYSTEMS

- Filter fabric shall not be used in or around underdrain trench.
- If there is less than 10 feet separation to the groundwater table, an impermeable fabric shall be placed at the base of the underdrain and the perforated pipe shall be placed on the impermeable fabric.
- The underdrain shall include a perforated pipe with cleanouts and connection to a storm drain or discharge point. Clean-out shall consist of a vertical, rigid, non-perforated PVC pipe, with a minimum diameter of 4 inches and a watertight cap fit flush with the ground, or as required by municipality.
- There shall be adequate fall from the underdrain to the storm drain or discharge point.

- Beginning December 1, 2011, soils in the area of inundation within the facility shall meet biotreatment soil specifications approved by the Regional Water Board (Appendix L). A minimum percolation rate of 5 inches per hour and a maximum percolation rate of 10 inches/hour are required (initial infiltration rate may exceed this to allow for tendency of infiltration rate to reduce over time).

CONSTRUCTION REQUIREMENTS FOR ALL BIOTREATMENT SYSTEMS

- When excavating, avoid spreading fines of the soils on bottom and side slopes. Remove any smeared soiled surfaces and provide a natural soil interface into which water may percolate.
- Minimize compaction of existing soils. Protect from construction traffic.
- Protect the area from construction site runoff. Runoff from unstabilized areas shall be diverted away from biotreatment facility.

MAINTENANCE CONSIDERATIONS FOR ALL TREATMENT MEASURES

- A Maintenance Agreement shall be provided.
- Maintenance Agreement shall state the parties' responsibility for maintenance and upkeep.
- Prepare a maintenance plan and submit with Maintenance Agreement. Maintenance plan templates are in Appendix H.

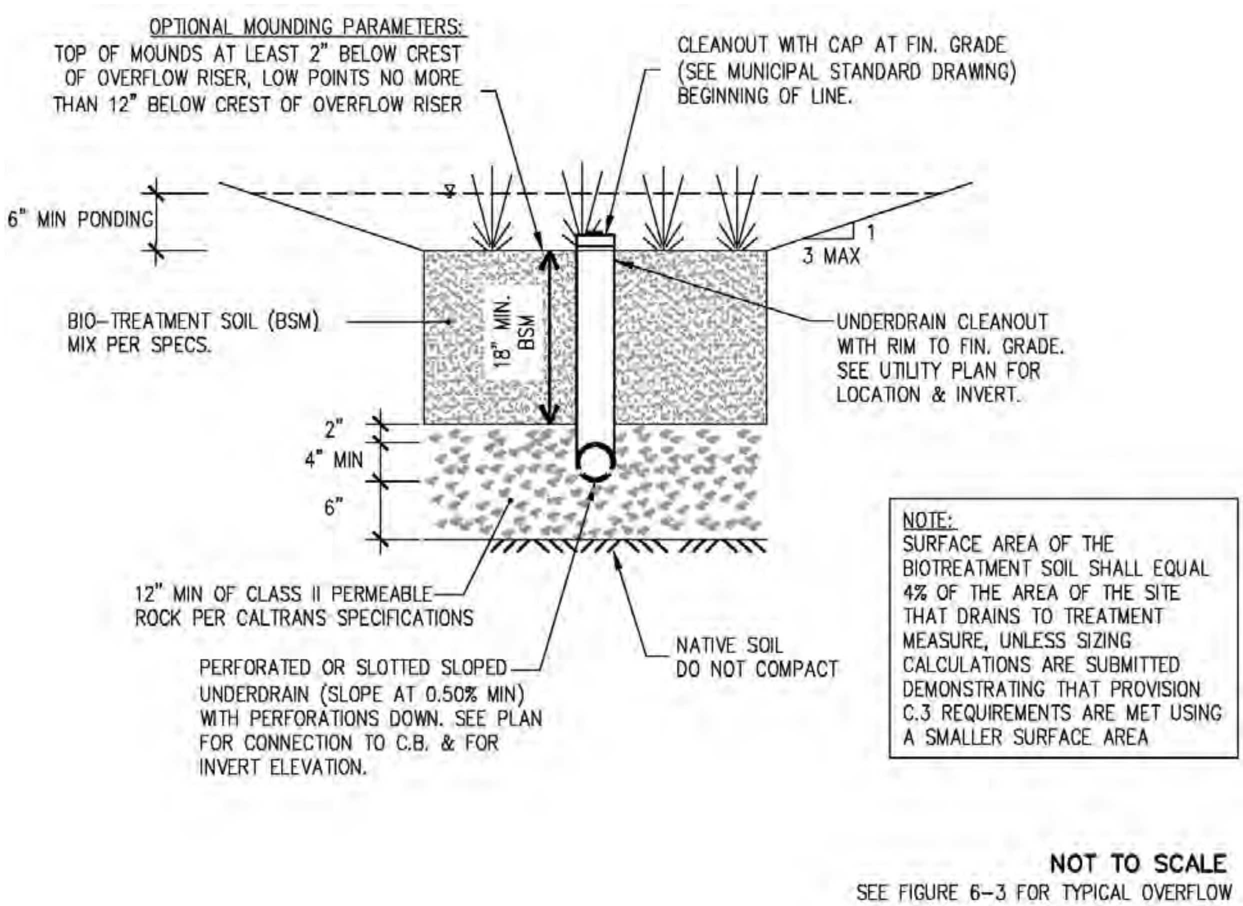


Figure 6-2: Cross Section, Bioretention Area

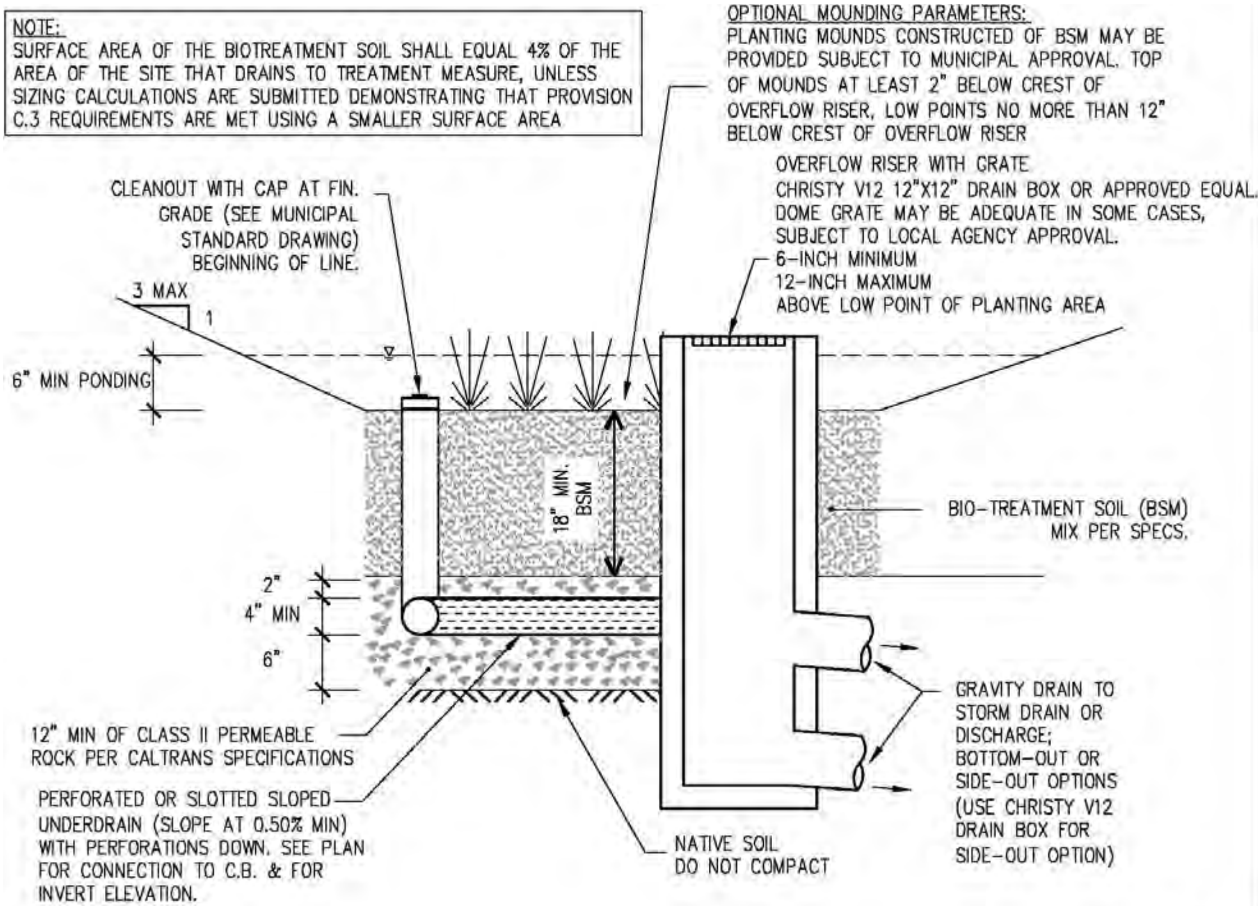


Figure 6-3: Cross Section, Bioretention Area (side view – Not to Scale)

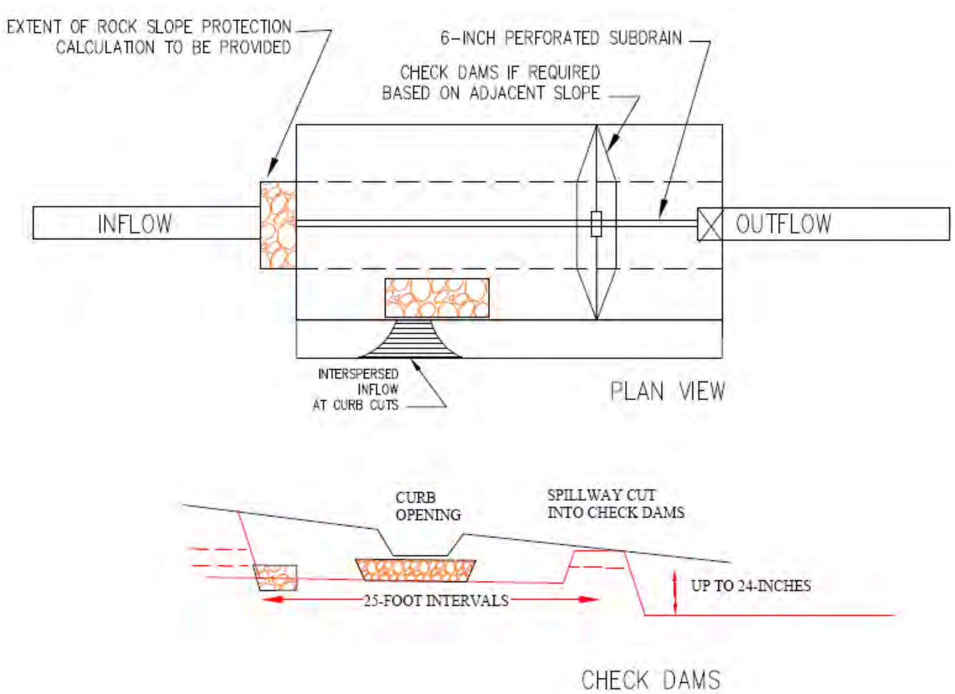


Figure 6-4: Check dam (plan view and profile) for installing a series of linear bioretention cells in sloped area

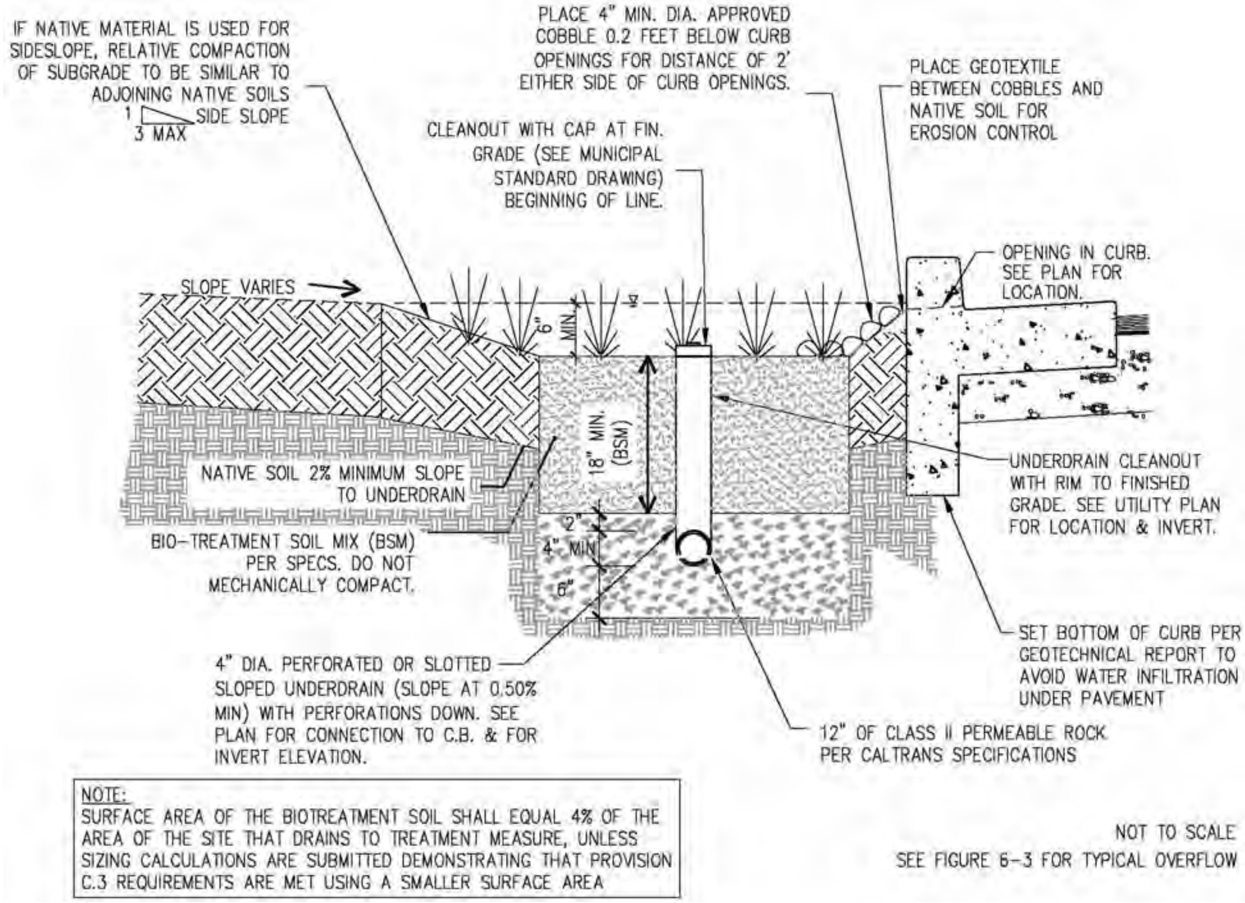


Figure 6-5: Cross-section of bioretention area showing inlet from pavement.

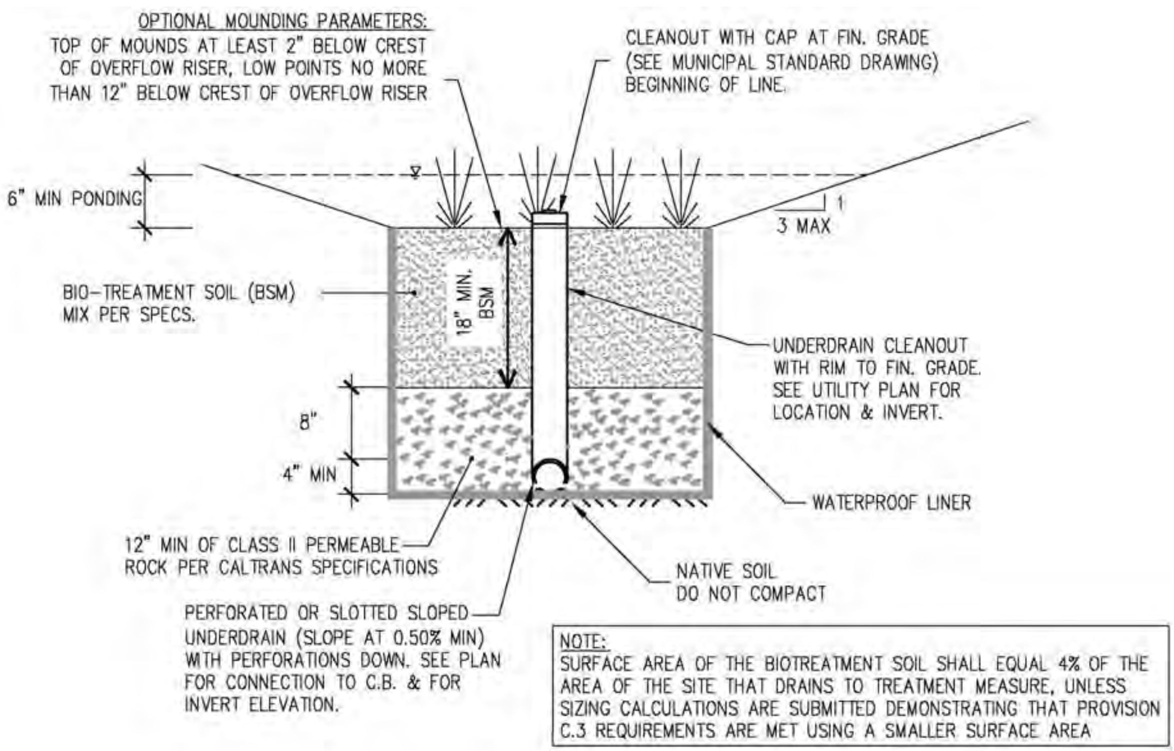


Figure 6-6: Cross section of lined bioretention area (Not to Scale)

6.2 Flow-Through Planter

Figure 6-7: At-grade flow-through planters. Source: City of Emeryville

Best uses

- Treating roof runoff
- Next to buildings
- Dense urban areas
- Locations where infiltration is not desired

Advantages

- Can be adjacent to structures
- Multi-use
- Versatile
- May be any shape
- Low maintenance

Limitations

- Requires sufficient head
- Careful selection of plants
- Requires level installation
- Susceptible to clogging

Flow-through planters are designed to treat and detain runoff without allowing seepage into the underlying soil. They can be used next to buildings and other locations where soil moisture is a potential concern. Flow-through planters typically receive runoff via downspouts leading from the roofs of adjacent buildings. However, flow-through planters can also be set level with the ground and receive sheet flow. Pollutants are removed as the runoff passes through the soil layer and is collected in an underlying layer of gravel or drain rock. A perforated pipe underdrain must be directed to a storm drain or other discharge point. An overflow inlet conveys flows that exceed the capacity of the planter.

Design and Sizing Guidelines

TREATMENT DIMENSIONS AND SIZING

- Flow-through planters may be designed with a 4% sizing factor (percentage of the surface area of planter compared to the surface area of the tributary impervious area). The area of impervious surface multiplied by 0.04 sizing factor will equal the footprint of the flow-through planter. Alternatively, calculations may be performed using either the hydraulic sizing criteria for flow-based treatment measures or the hydraulic sizing criteria for combination flow- and volume-based treatment measures, included in Section 5.1.
- Install an overflow weir adequate to meet municipal drainage requirements.
- Flow-through planters can be used adjacent to building and within set back area.
- Flow-through planters can be used above or below grade.
- Size overflow trap for building code design storm, set trap below top of planter box walls.
- Planter wall set against building should be higher to avoid overflow against building.
- Elevation of the surface area may vary as needed to distribute stormwater flows throughout the surface area.

- Minimum 2 and up to12 inches of water surface storage between the planting surface and crest of overflow weir.

VEGETATION

- Plantings should be selected for viability in a well-drained soil. See planting guidance in Appendix B.
- Use integrated pest management (IPM) principles in the landscape design to help avoid or minimize any use of synthetic pesticides and quick-release fertilizer. Check with the local jurisdiction for any local policies regarding the use of pesticides and fertilizers.
- Irrigation shall be provided, as needed, to maintain plant life.
- Trees and vegetation do not block inflow, create traffic or safety issues, or obstruct utilities.

INLETS TO TREATMENT MEASURE

Flow may enter the treatment measure (see example drawings in Section 5.10):

  - As overland flow from landscaping (no special requirements)
  - As overland flow from pavement (cutoff wall required)
  - Through a curb opening (minimum 18 inches)
  - Through a curb drain
  - With drop structure through a stepped manhole (refer to Figure 5-4 in Chapter 5)
  - Through a bubble-up manhole or storm drain emitter
  - Through roof leader or other conveyance from building roof
- Where flows enter the biotreatment measure, allow a change in elevation of 4 to 6 inches between the paved surface and biotreatment soil elevation, so that vegetation or mulch build-up does not obstruct flow.
- Splash blocks, cobbles or rocks shall be installed to dissipate flow energy where runoff enters the treatment measure.
- For long linear planters, space inlets to planter at 10-foot intervals or install flow spreader.

SOIL CONSIDERATIONS SPECIFIC TO FLOW THROUGH PLANTERS

- Waterproofing shall be installed as required to protect adjacent building foundations.
- If site conditions permit infiltration to underlying soils, waterproofing is not required.
- An underdrain system is generally required for flow through planters. Depending on the infiltration rate of in situ soils, the local jurisdiction may allow installation without an underdrain on a case-by-case basis.
- Underdrain trench shall include a 12-inch thick layer of Caltrans Standard Section 68-1.025 permeable material Class 2. Minimum 4-inch diameter perforated pipe shall be placed within backfill layer. To help prevent clogging, two rows of perforation may be used.
- Planting soil shall have a minimum percolation rate of 5 inches per hour and a maximum percolation rate of 10 inches/hour. Soil specifications are provided in Appendix L. Check with municipality for any additional requirements.
- The planting soil shall be at least 18 inches thick.
- Provide 3-inch layer of mulch in areas between plantings.

SOIL CONSIDERATIONS FOR ALL BIOTREATMENT SYSTEMS

- Beginning December 1, 2011, soils in the area of inundation within the facility shall meet biotreatment soil specifications approved by the Regional Water Board (Appendix L). A minimum percolation rate of 5 inches per hour and a maximum percolation rate of 10 inches/hour are required (initial infiltration rate may exceed this to allow for tendency of infiltration rate to reduce over time).

- Filter fabric shall not be used in or around underdrain trench.
- The underdrain shall include a perforated pipe with cleanouts and connection to a storm drain or discharge point. Clean-out shall consist of a vertical, rigid, non-perforated PVC pipe, with a minimum diameter of 4 inches and a watertight cap fit flush with the ground.
- There shall be adequate fall from the underdrain to the storm drain or discharge point.

CONSTRUCTION REQUIREMENTS FOR ALL BIOTREATMENT SYSTEMS

- When excavating, avoid spreading fines of the soils on bottom and side slopes. Remove any smeared soiled surfaces and provide a natural soil interface into which water may percolate.
- Minimize compaction of existing soils. Protect from construction traffic.
- Protect the area from construction site runoff. Runoff from unstabilized areas shall be diverted away from biotreatment facility.

MAINTENANCE CONSIDERATIONS FOR ALL TREATMENT MEASURES

- A Maintenance Agreement shall be provided.
- Maintenance Agreement shall state the parties' responsibility for maintenance and upkeep.
- Prepare a maintenance plan and submit with Maintenance Agreement. Maintenance plan templates are in Appendix H.

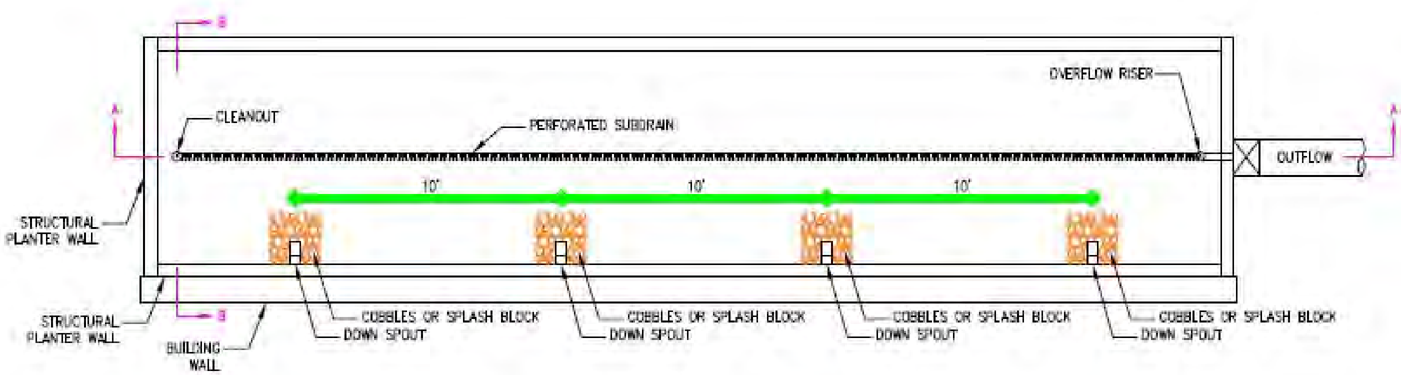


Figure 6-8: Plan view of long, linear planter, with inlets to the planter distributed along its length at 10' intervals.

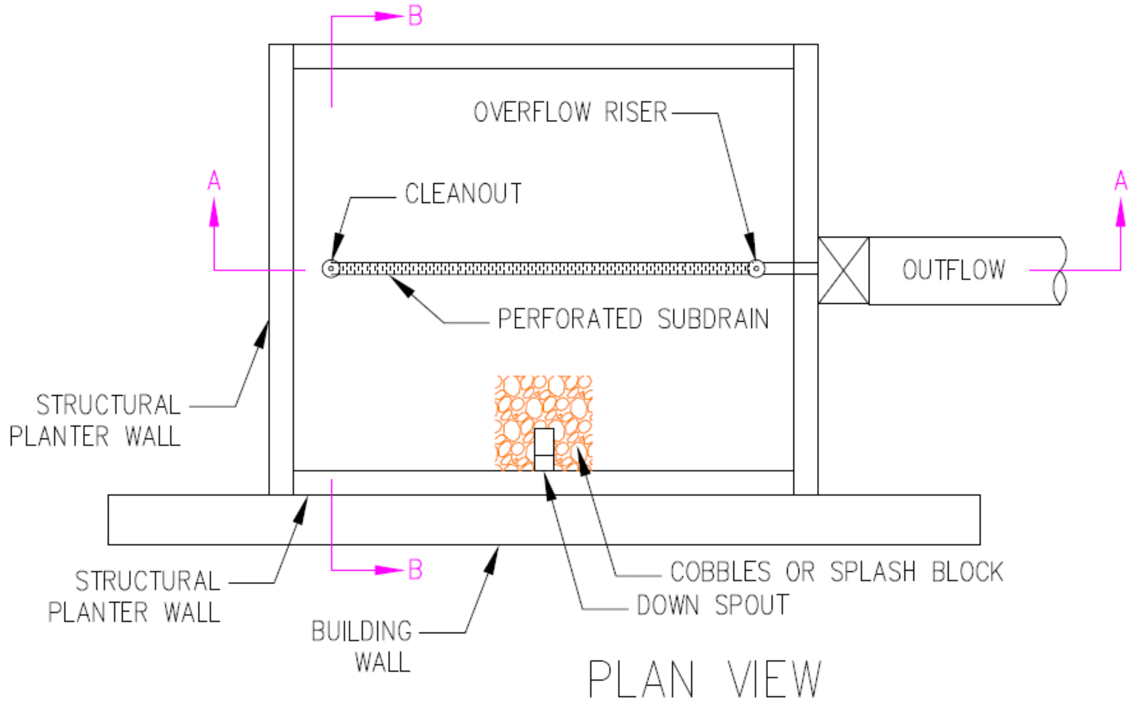


Figure 6-9: Plan view of planter designed to disperse flows adequately with only one inlet to planter

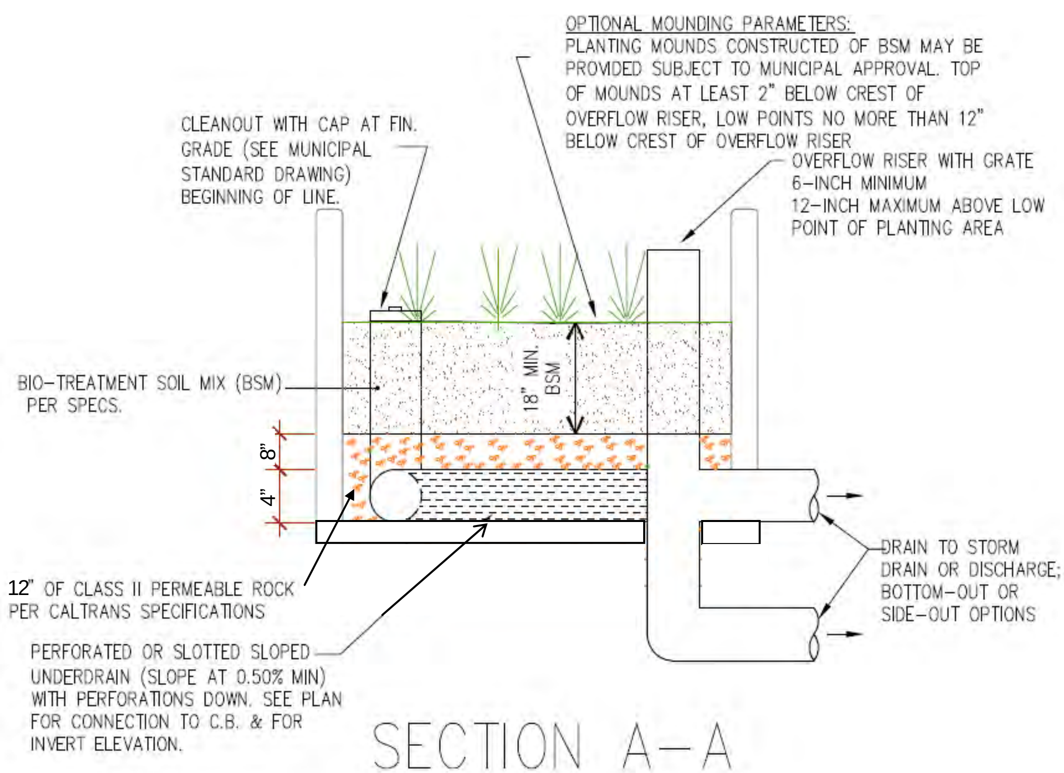


Figure 6-10: Cross section A-A of flow-through planter, shows side view of underdrain

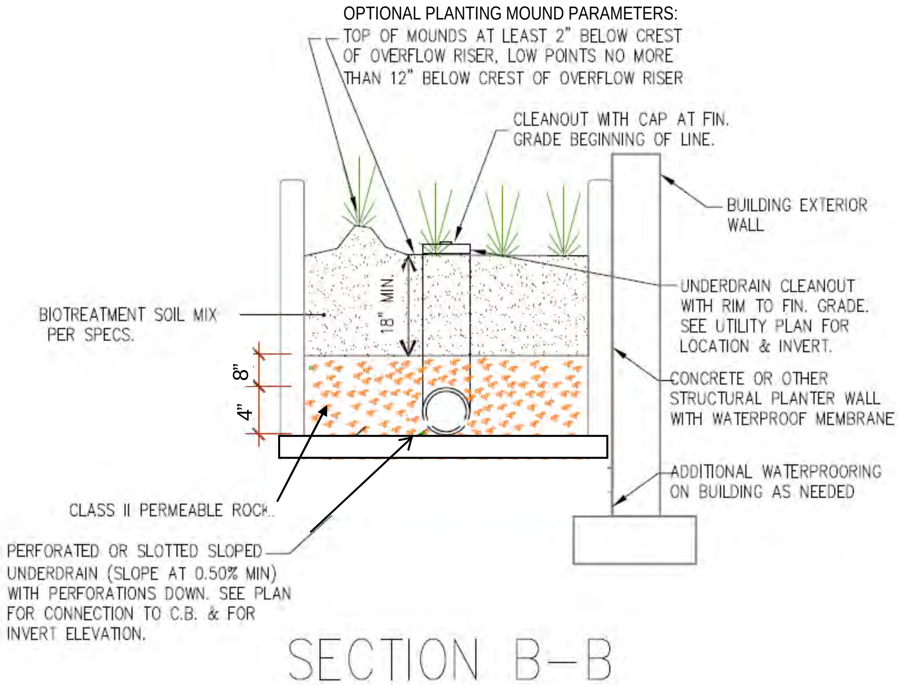


Figure 6-11: Cross section B-B of flow-through planter, shows cross section of underdrain

Figure 6-12: Half-buried, perforated flexible pipe serves as a flow spreader to distribute stormwater evenly throughout long, linear flow-through planter in Emeryville (Source: GreenGrid/ Weston Solutions).

Figure 6-13: The same planter as shown in Figure 6-12, after vegetation has matured and partially conceals the half-buried pipe from view (Source: San Francisco Estuary Partnership).

6.3 Tree Well Filter

Figure 6-14: Non-proprietary tree well filters in Fremont use bio-retention soils with an infiltration rate of 5 to 10 inches per hour. Spacing the units closely together provides a total tree well filter surface area that is 4 percent of the impervious surface area from which stormwater runoff is treated.

Best Uses

- Special Projects, per Appendix K
- Limited space
- Parallel to roadways

Advantages

- Aesthetic
- Small surface land use
- Blends with the landscape

Limitations

- Can clog without maintenance
- High installation cost
- Systems with very high infiltration rates are allowed ***only in Special Projects beginning December 2011***

Tree well filters are especially useful in settings where available space is at a premium. They can be installed in open- or closed-bottom chambers where infiltration is undesirable or not possible, such as tight clay soils, sites with high groundwater, or areas with highly contaminated runoff. Tree well filters may be installed along urban sidewalks, but they are highly adaptable and can be used in most development scenarios. In urban areas, tree filters can be used in the design of an integrated street landscape – a choice that transforms isolated street trees into stormwater filtration devices. In general, tree well filters are sized and spaced much like catch basin inlets, and design variations are abundant. The tree well filter's basic design is a vault filled with bioretention soil mix, planted with vegetation, and underlain with a subdrain. ***Beginning December 1, 2011,*** manufactured tree well filters, and other tree well filters with long-term rates of infiltration that exceed 10 inches per hour, will be allowed only in Special Projects, as described in Appendix K.

Design and Sizing Guidelines

- Flows in excess of the treatment flow rate shall bypass the tree filter to a downstream inlet structure or other appropriate outfall.
- Tree filters cannot be placed in sump condition; therefore tree filters shall have flow directed along a flow line of curb and gutter or other lateral structure. Do not direct flows directly to a tree filter.
- If a proprietary tree well filter is used, and until there are results demonstrating effectiveness in the Bay Area, the capacity of the installed manufactured tree filter unit shall be twice the capacity that is predicted to be required for the device.

- If a proprietary tree filter is used, it shall be reviewed by the manufacturer before installation.
- For proprietary tree filters, manufacturer will size the tree filter to the impervious surface of a site. The manufacturer shall certify the ratio of impervious area to treatment area for the project. For example, Filterra states that a tree filter of 6 x 6-feet can treat 0.25 acres of impervious surface.
- Proprietary tree filters are available in multi-sized pre-cast concrete drop in boxes, Sizes range from 4 x 6-feet up to 6 x 12-feet boxes.

INLETS TO TREATMENT MEASURE

Flow may enter the treatment measure (see example drawings in Section 5.10):

  - As overland flow from landscaping (no special requirements)
  - As overland flow from pavement (cutoff wall required)
  - Through a curb opening (minimum 18 inches)
  - Through a curb drain
  - With drop structure through a stepped manhole (refer to Figure 5-4 in Chapter 5)
  - Through a bubble-up manhole or storm drain emitter
  - Through roof leader or other conveyance from building roof
- Where flows enter the biotreatment measure, allow a change in elevation of 4 to 6 inches between the paved surface and biotreatment soil elevation, so that vegetation or mulch build-up does not obstruct flow.
- Cobbles or rocks shall be installed to dissipate flow energy where runoff enters the treatment measure.

VEGETATION

- Suitable plant species are identified in Appendix B planting guidance.
- Use integrated pest management (IPM) principles in the landscape design to help avoid or minimize any use of synthetic pesticides and quick-release fertilizer. Check with the local jurisdiction for any local policies regarding the use of pesticides and fertilizers.
- Irrigation shall be provided, as needed, to maintain plant life.
- Trees and vegetation do not block inflow, create traffic or safety issues, or obstruct utilities.

SOIL REQUIREMENTS SPECIFIC TO TREE WELL FILTERS

- Filter media in tree well filter shall be specialized for expected site pollutant loads.
- Beginning December 1, 2011, if the long-term infiltration rate of media exceeds 10 inches per hour, use of the tree well filter will not be allowed, except for Special Projects (see Appendix K).
- An underdrain system is required for tree well filters.
- Underdrain trench shall include a 12-inch thick layer Caltrans Standard Section 68-1.025 permeable material Class 2. A minimum 4-inch diameter perforated pipe shall be placed within the backfill layer. To help prevent clogging, two rows of perforation may be used.
- If there is at least a 10-foot separation between the base of the underdrain and the groundwater table, there shall be at least 6-inch separation between the perforated pipe and the base of the trench to allow percolation.

SOIL CONSIDERATIONS FOR ALL BIOTREATMENT SYSTEMS

- If there is less than 10 feet separation to the groundwater table, an impermeable fabric shall be placed at the base of the underdrain and the perforated pipe shall be placed on the impermeable fabric.
- Filter fabric shall not be used in or around underdrain trench.
- The underdrain shall include a perforated pipe with cleanouts and connection to a storm drain or discharge point. Clean-out shall consist of a vertical, rigid, non-perforated PVC pipe, with a minimum diameter of 4 inches and a watertight cap fit flush with the ground, or as required by municipality.
- There shall be adequate fall from the underdrain to the storm drain or discharge point.
- Beginning December 1, 2011, soils in the area of inundation within the facility shall meet biotreatment soil specifications approved by the Regional Water Board (Appendix L). A minimum percolation rate of 5 inches per hour and a maximum percolation rate of 10 inches/hour are required (initial infiltration rate may exceed this to allow for tendency of infiltration rate to reduce over time).

CONSTRUCTION REQUIREMENTS FOR ALL BIOTREATMENT SYSTEMS

- When excavating, avoid spreading fines of the soils on bottom and side slopes. Remove any smeared soiled surfaces and provide a natural soil interface into which water may percolate.
- Minimize compaction of existing soils. Protect from construction traffic.
- Protect the area from construction site runoff. Runoff from unstabilized areas shall be diverted away from biotreatment facility.

MAINTENANCE CONSIDERATIONS FOR ALL TREATMENT MEASURES

- A Maintenance Agreement shall be provided.
- Maintenance Agreement shall state the parties' responsibility for maintenance and upkeep.
- Prepare a maintenance plan and submit with Maintenance Agreement. Maintenance plan templates are in Appendix H.

Figure 6-15: Non-proprietary Tree Filter with Overflow Bypass. Source: University of New Hampshire Environmental Research Group, 2006

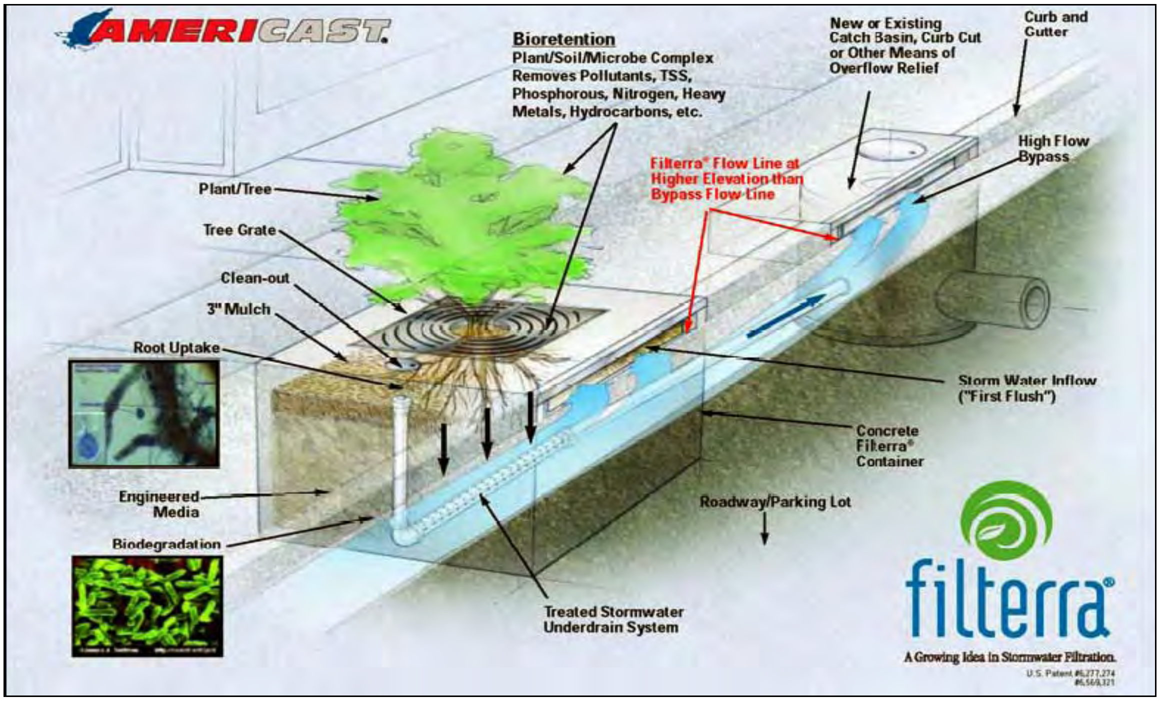


Figure 6-16: Cut-away view of proprietary tree well filter. Source: Americast, 2006. The use of this photo is for general information only, and is not an endorsement of this or any other proprietary stormwater treatment device.

6.4 Vegetated Buffer Strip

Figure 6-17: Vegetated buffer strip. Source: www.cabmphandbooks.com

Best Uses
- Roadside shoulders
- Landscape buffer

Advantages
- Minimal maintenance
- Reliable
- Aesthetic appeal
- Adjustable to suit site

Limitations
- No large drainage areas
- Thick cover necessary
- Large size requirements
- Minimal detention provided

Vegetated buffer strips (grassed buffer strips, filter strips, and grassed filters) are vegetated surfaces that are designed to treat sheet flow from adjacent surfaces. Vegetated buffer strips function by slowing runoff velocities and allowing sediment and other pollutants to settle and by providing some infiltration into underlying soils. Vegetated buffer strips were originally used as an agricultural treatment practice and have more recently evolved into an urban practice. With proper design and maintenance, vegetated buffer strips can provide relatively high pollutant removal. In addition, the public views them as landscaped amenities and not as stormwater infrastructure.

Design and Sizing Guidelines

TREATMENT DIMENSIONS AND SIZING

- Strip shall be sized as long as the site will reasonably allow. The width in the direction of flow shall be at least:
  - 5 feet where the length of flow across an impervious surface is less than 10-feet in the direction of flow.
  - At least 50 percent of the length of flow across an impervious surface where the length of flow across an impervious surface is between 10 and 30 feet in the direction of flow.
  - At least 15 feet where the length of flow across an impervious surface is between 30 feet and 60 feet in the direction of flow.
- Level spreaders shall be used if the length of flow across an impervious surface is greater than 60 feet in the direction of flow. The level spreader shall distribute flows over a length that will provide equivalent discharge per linear foot of level spreader as if the flow to the vegetated buffer strip was from a surface with 60-feet length in the direction of flow.
- Slopes should not exceed 1-foot Vertical to 4-foot Horizontal (1:4).
- Strip shall be free of gullies or rills.

VEGETATION

- Either grass or a diverse selection of other low growing, drought tolerant, native vegetation should be specified. Vegetation whose growing season corresponds to the wet season is preferred. See planting guidance in Appendix B.
- Use integrated pest management (IPM) principles in the landscape design to help avoid or minimize any use of synthetic pesticides and quick-release fertilizer. Check with the local jurisdiction for any local policies regarding the use of pesticides and fertilizers.
- Irrigation shall be provided, as needed, to maintain plant life.
- Trees and vegetation do not block inflow, create traffic or safety issues, or obstruct utilities.

INLETS

- Flow may enter the treatment measure (see example drawings in Section 5.10):
    - As overland flow from landscaping (no special requirements)
    - As overland flow from pavement (cutoff wall required)
    - Through a curb opening (minimum 18 inches)
    - Through a curb drain
    - With drop structure through a stepped manhole (refer to Figure 5-4 in Chapter 5)
    - Through a bubble-up manhole or storm drain emitter
    - Through roof leader or other conveyance from building roof
- Where flows enter the biotreatment measure, allow a change in elevation of 4 to 6 inches between the paved surface and biotreatment soil elevation, so that vegetation or mulch build-up does not obstruct flow.
- If runoff is piped or channeled to the strip, a level spreader must be installed to create sheet flow.
- Flows from the buffer strip must concentrate sheet flows for discharge to storm drain system. This may be accomplished with a trench drain, vegetated conveyance swale, or other method approved by the municipality.

SOIL CONSIDERATIONS SPECIFIC TO VEGETATED BUFFER STRIPS

- Check with municipality for planting soil requirements. Until December 1, 2011, and except where other municipal requirements apply, planting soil shall have a minimum percolation rate of 2 inches per hour and a maximum percolation rate of 10 inches/hour. If native soils do not meet this percolation requirement, import soil meeting the Clean Water Program's dewatering soil specifications shall be used in the area of inundation.
- Planting soil will be to a minimum depth of at least 6 inches.
- No underdrain trench is needed where native soils are Hydrologic Soil Group A or B.
- When placed on native hydrologic soil group C and D soils, drainage must be provided to allow gravity drainage of the treatment soils. This may consist of underdrain trenches or other means to assure that the biotreatment soil is able to fully dewater after storm event.
- Underdrain trench shall include a 12-inch thick layer of Caltrans Standard Section 68-1.025 permeable material Class 2. A minimum 4-inch diameter perforated pipe shall be placed within the backfill layer. To help prevent clogging, two rows of perforation may be used.
- If there is at least a 10-foot separation between the base of the underdrain and the groundwater table, there shall be at least 6-inch separation between the perforated pipe and the base of the trench to allow percolation.
- Provide 3-inch layer of mulch in areas between plantings.

SOIL CONSIDERATIONS FOR ALL BIOTREATMENT SYSTEMS

- If there is less than 10 feet separation to the groundwater table, an impermeable fabric shall be placed at the base of the underdrain and the perforated pipe shall be placed on the impermeable fabric.
- No filter fabric shall be used in or around underdrain trench.
- The underdrain shall include a perforated pipe with cleanouts and connection to a storm drain or discharge point. Clean-out shall consist of a vertical, rigid, non-perforated PVC pipe, with a minimum diameter of 4 inches and a watertight cap fit flush with the ground.
- There shall be adequate fall from the underdrain to the storm drain or discharge point.
- Beginning December 1, 2011, soils in the area of inundation within the facility shall meet biotreatment soil specifications approved by the Regional Water Board (Appendix L). The minimum percolation rate for the biotreatment soil is 5 inches per hour. The long-term desired maximum infiltration rate is 10 inches per hour, although initial infiltration rate may exceed this to allow for tendency of infiltration rate to reduce over time.

CONSTRUCTION REQUIREMENTS FOR ALL BIOTREATMENT SYSTEMS

- When excavating, avoid spreading fines of the soils on bottom and side slopes. Remove any smeared soiled surfaces and provide a natural soil interface into which water may percolate.
- Minimize compaction of existing soils. Protect from construction traffic.
- Protect the area from construction site runoff. Runoff from unstabilized areas shall be diverted away from biotreatment facility.

MAINTENANCE CONSIDERATIONS FOR ALL TREATMENT MEASURES

- A Maintenance Agreement shall be provided.
- Maintenance Agreement shall state the parties' responsibility for maintenance and upkeep.
- Prepare a maintenance plan and submit with Maintenance Agreement. Maintenance plan templates are in Appendix H.

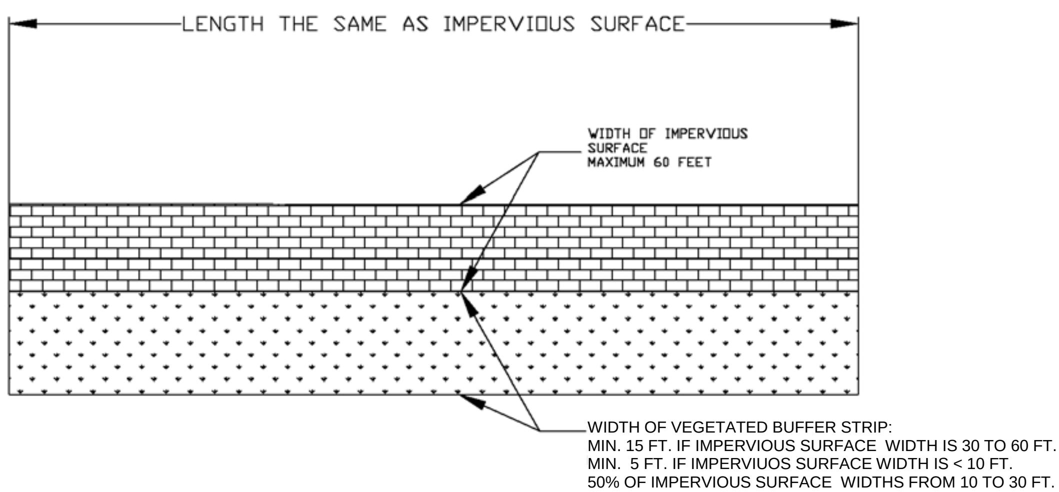
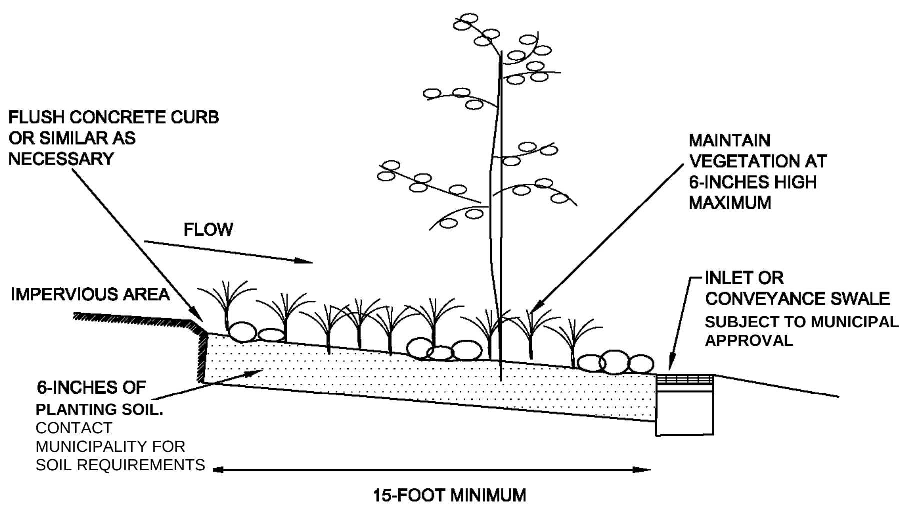


Figure 6-18: Plan View, Vegetated Buffer Strip



PLANTING SOIL WILL BE OF A MINIMUM DEPTH OF AT LEAST 6 INCHES.

15% MAXIMUM SLOPE, 2% MINIMUM SLOPE, 0.5% MINIMUM SLOPE WITH UNDERDRAIN,

LONGITUDINAL LENGTH = LONGITUDINAL LENGTH OF CONTRIBUTING AREA

STRIP SHALL BE FREE OF GULLIES OR RILLS.

Figure 6-19: Profile View, Vegetated Buffer Strip

6.5 Infiltration Trench

Figure 6-20: Infiltration trench. Source: CASQA, 2003

Best Uses

- Limited space
- Adjacent to roadways
- Landscape buffers

Advantages

- Increases groundwater recharge
- Removes suspended solids
- No surface outfalls

Limitations

- Susceptible to clogging; fails with no maintenance
- No high water tables
- Infiltration rate of existing soils must exceed 0.5 in/hr
- No steep slopes
- Drainage area less than 5 acres

An infiltration trench is a long, narrow, excavated trench backfilled with a stone aggregate, and lined with a filter fabric. Runoff is stored in the void space between the stones and infiltrates through the bottom and into the soil matrix. Pretreatment using buffer strips, swales, or detention basins is important for limiting amounts of coarse sediment, which can clog and render the trench ineffective. Infiltration practices, such as infiltration trenches, remove suspended solids, particulate pollutants, coliform bacteria, organics, and some soluble forms of metals and nutrients from stormwater runoff. The infiltration trench treats the design volume of runoff either underground or at grade. Pollutants are filtered out of the runoff as it infiltrates the surrounding soils. Infiltration trenches also provide groundwater recharge and preserve base flow in nearby streams. Infiltration trenches have a high rate of failure where soil conditions are not suitable.

Design and Sizing Guidelines

DRAINAGE AREA AND SETBACK CONSIDERATIONS

- When the drainage area exceeds 5 acres, other treatment measures shall be considered.
- Infiltration trenches work best when the upgradient drainage area slope is less than 5 percent. The downgradient slope shall be no greater than 20 percent to minimize slope failure and seepage.
- In-situ/undisturbed soils shall have a low silt and clay content and have percolation rates greater than 0.5 inches per hour. In-situ testing is required to confirm percolation rate of trench site. CASQA's BMP Handbook recommends against using infiltration trenches in Type C or D soils.
- There shall be at least 10 feet between the bottom of the trench and the groundwater table to prevent potential groundwater problems.
- Trenches shall also be located at least 100 feet upgradient from water supply wells.

- A setback of 100 feet from building foundations is recommended, unless a smaller setback is approved by geotechnical engineer and local standard.

TREATMENT DIMENSIONS AND SIZING

- The infiltration trench shall be sized to store the full 48-hour water quality volume.
- A site-specific trench depth can be calculated based on the soil infiltration rate, aggregate void space, and the trench storage time. The stone aggregate used in the trench is normally 1.5 to 2.5 inches in diameter, which provides a void space of 35 to 40 percent. A minimum drainage time of 6 hours shall be provided to ensure satisfactory pollutant removal in the infiltration trench. Trenches may be designed to provide temporary storage of storm water. Trench depths are usually between 3 and 8 feet, with a depth of 8 feet most commonly used.
- The trench surface may consist of stone or vegetation (contact local municipality to determine if vegetation is allowed) with inlets to evenly distribute the runoff entering the trench. Runoff can be captured by depressing the trench surface or by placing a berm at the down gradient side of the trench. The basic infiltration trench design utilizes stone aggregate in the top of the trench to promote filtration; however, this design can be modified by substituting pea gravel for stone aggregate in the top 1-foot of the trench. Typically, there is about 35 to 40% void space within the rock.
- Use trench rock that is 1.5 to 2.5 inches in diameter or pea gravel to improve sediment filtering and maximize the pollutant removal in the top 1 foot of the trench.
- Place permeable filter fabric around the walls and bottom of the trench and 1 foot below the trench surface. The filter fabric shall overlap each side of the trench in order to cover the top of the stone aggregate layer. The filter fabric prevents sediment in the runoff and soil particles from the sides of the trench from clogging the aggregate. Filter fabric that is placed 1 foot below the trench surface will maximize pollutant removal within the top layer of the trench and decrease the pollutant loading to the trench bottom, reducing frequency of maintenance.
- The infiltration trench shall drain within 5 days to avoid vector generation.
- An observation well is recommended to monitor water levels in the trench. The well can be 4 to 6-inch diameter PVC pipe, which is anchored vertically to a foot plate at the bottom of the trench.

INLET TO THE TREATMENT MEASURE

- A vegetated buffer strip at least 5-feet wide, swale or detention basin shall be established adjacent to the infiltration trench to capture large sediment particles in the runoff before runoff enters the trench. If a buffer strip or swale is used, installation should occur immediately after trench construction using sod instead of hydroseeding. The buffer strip shall be graded with a slope between 0.5 and 15 percent so that runoff enters the trench as sheet flow. The vegetated swale or detention basin shall be sized according to Sections 6.4 and 6.7 respectively.
- If runoff is piped or channeled to the trench, a level spreader shall be installed to create sheet flow.

IF VEGETATION IS ALLOWED AT TRENCH SURFACE

- Infiltration trenches can be modified by adding a layer of organic material (peat) or loam to the trench subsoil. This modification enhances the removal of metals and nutrients through adsorption. The modified trenches are then covered with a permeable geotextile membrane overlain with topsoil and grass or stones.

- If surface landscaping of the trench is desired, contact local municipality to determine if this is allowed.
- Plant species should be suitable to well-drained soil. See planting guidance in Appendix B.
- Use integrated pest management (IPM) principles in the landscape design to help avoid or minimize any use of synthetic pesticides and quick-release fertilizer. Check with the local jurisdiction for any local policies regarding the use of pesticides and fertilizers.
- Irrigation shall be provided as needed to maintain plant life.

CON STRUCTION REQUIREMENTS

- The drainage area must be fully developed and stabilized with vegetation before constructing an infiltration trench. High sediment loads from unstabilized areas will quickly clog the infiltration trench. During project construction, runoff from unstabilized areas shall be diverted away from the trench into a sedimentation control BMP until vegetation is established.
- When excavating, avoid spreading fines of the soils on bottom and sides. Remove any smeared soiled surfaces and provide a natural soil interface into which water may percolate.
- Minimize compaction of existing soils. Protect from construction traffic.

MAINTENANCE CONSIDERATIONS FOR ALL TREATMENT MEASURES

- A Maintenance Agreement shall be provided.
- Maintenance Agreement shall state the parties' responsibility for maintenance and upkeep.
- Prepare a maintenance plan and submit with Maintenance Agreement. Maintenance plan templates are in Appendix H.

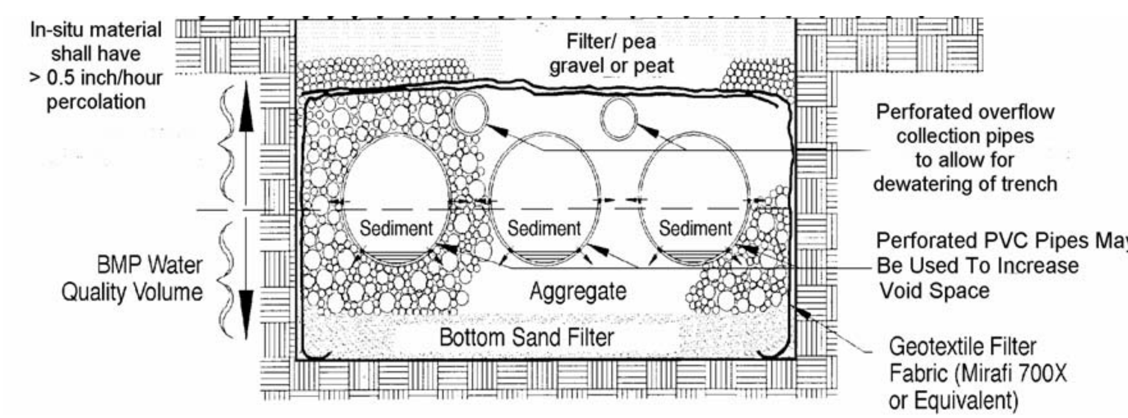


Figure 6-21: Infiltration trench cut-away view

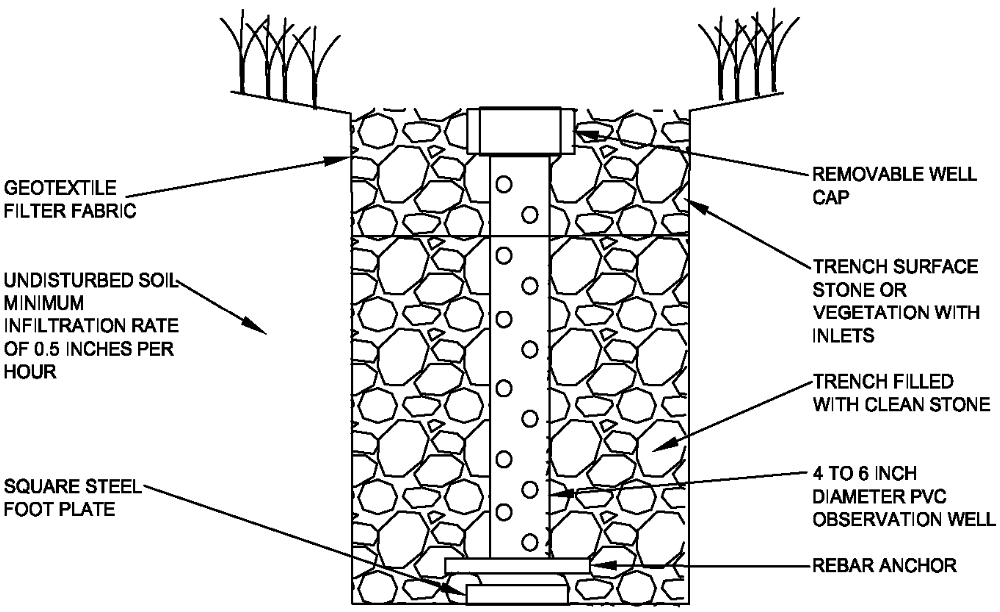


Figure 6-22: Observation Well Detail: Infiltration Trench

6.6 Extended Detention Basin

Figure 6-23: Extended detention basin. Source: California BMP Handbook (CASQA, 2003)

Best uses

- Detain low flows
- Can be expanded to detain peak flows
- Sedimentation of suspended solids
- Sites larger than 5 acres

Advantages

- Easy to operate
- Inexpensive to construct
- Treatment of particulates
- Low maintenance

Limitations

- Land requirements
- Not a stand-alone treatment measure after 12/1/11

Extended detention ponds (a.k.a. dry ponds, dry extended detention basins, detention ponds, extended detention ponds) are basins whose outlets have been designed to detain the stormwater runoff from a water quality design storm for a minimum of 48 hours to allow particles and associated pollutants to settle. Unlike wet ponds, these facilities do not have a permanent pool. They can also be used to provide hydromodification management and/or flood control by including additional flow duration control and/or flood detention storage above the treatment storage area.

Beginning December 1, 2011, projects will no longer be allowed to meet stormwater treatment requirements with stand-alone extended detention basins that are designed to treat stormwater through the settling of pollutants and gradual release of detained stormwater through an orifice. However, this type of extended detention basin could be used as part of a treatment train, in which the basin stores a large volume of water, which is gradually released to a bioretention area that meets the new MRP requirements for biotreatment soils and surface loading area.

Design and Sizing Guidelines

TREATMENT DIMENSIONS AND SIZING

- Extended detention basins shall be sized to capture the required water quality volume over at least a 48-hour period. At least 10 percent additional storage shall be provided to account for storage lost to deposited sediment.
- Extended detention basin shall have no greater than 3:1 side slopes.
- The optimal basin depth is between 2 and 5 feet.
- A safety bench shall be added to the perimeter of the basin wall for maintenance when basin is full.

- Extended detention basin shall empty within five days of the end of a 6-hour, 100-year storm event to avoid vector generation.
- A 12-foot wide maintenance ramp leading to the bottom of the basin and a 12-foot wide perimeter access road shall be provided. If not paved, the ramp shall have a maximum slope of 5 percent. If paved, the ramp may slope 12 percent.
- The extended detention basin shall have a length to width ratio of at least 1.5:1.
- A fixed vertical sediment depth marker shall be installed in the sedimentation forebay. The depth marker shall have a marking showing the depth where sediment removal is required. The marking shall be at a depth where the remaining storage equals the design water quality volume.
- The detention basin is a volume-based treatment measure and requires detention time to be effective. The basin shall not empty more than 50% of its treatment volume in less than 24 hours to allow settling of sediment and associated pollutants.

INLETS TO TREATMENT MEASURE

- The inlet pipe shall have at least 1 foot of clearance to the basin bottom.
- Piping into the extended detention basin shall have erosion protection. As a minimum, a forebay with a 6-inch thick layer of Caltrans Section 72, Class 2 rock slope protection shall be placed at and below the inlet to the extent necessary for erosion protection.
- Check with municipality regarding trash screen requirements. Trash screen installation may be required upstream of the pipe conveying water into the pond, in order to capture litter and trash in a central location where it can be kept out of the pond until it is removed.

OUTLETS AND ORIFICES

- The outlet shall be sized with a drawdown time of 48 hours for the design water quality volume. The outlet shall have two orifices at the same elevation sized using the following equation:

$$a = (7x10^{-5}) * A * (H\text{-}Ho)^{.5} \ / \ CT$$

Where:

a = area of each orifice in square feet
A = surface area of basin at mid-treatment storage elevation (square feet)
H = elevation of basin when filled by water treatment volume (feet)
Ho = final elevation of basin when empty (bottom of lowest orifice) (feet)
C = orifice coefficient (0.6 typical for drilled orifice)
T = drawdown time of full basin (hours)

(Caltrans Method, Appendix B, Stormwater Quality Handbook, September 2002)

- Orifices shall each be a minimum diameter of 1 inch. Extended detention basins are not practical for small drainage areas because the minimum orifice diameter cannot be met.
- Each orifice shall be protected from clogging using a screen with a minimum surface area of 50 times the surface area of the openings to a height of at least 6 times the diameter. The screen shall protect the orifice openings from runoff on all exposed sides.
- For each outlet, provide documentation regarding adequacy of outlet protection, and a larger stone size may be necessary depending on the slope and the diameter of the outfall.

VEGETATION

- Plant species should be adapted to periods of inundation. See planting guidance in Appendix B.

- Use integrated pest management (IPM) principles in the landscape design to help avoid or minimize any use of synthetic pesticides and quick-release fertilizer. Check with the local jurisdiction for any local policies regarding the use of pesticides and fertilizers.
- Irrigation shall be provided as needed to maintain plant life.
- If vegetation is not established by October 1st, sod shall be placed over loose soils. Above the area of inundation, a 1-year biodegradable loose weave geofabric may be used in place of sod.

SOIL CONSIDERATIONS

- If the groundwater level is within 10 feet of the ground surface, a liner shall be provided.
- Beginning December 1, 2011, if the extended detention basin is designed to meet biotreatment requirements, soils in the area of inundation within the facility shall meet biotreatment soil specifications approved by the Regional Water Board (Appendix L). The minimum percolation rate for the biotreatment soil is 5 inches per hour. The long-term desired maximum infiltration rate is 10 inches per hour, although initial infiltration rate may exceed this to allow for tendency of infiltration rate to reduce over time.
- Also beginning December 1, 2011, if the extended detention basin is designed to meet biotreatment requirements, the surface area shall be no smaller than what is required to accommodate a 5" per hour stormwater runoff surface loading rate. This may be accomplished using a combination flow and volume design basis described in Section 5.1.
- Beginning December 1, 2011, if the extended detention basin is NOT designed to meet biotreatment requirements, it cannot function as a stand-alone treatment measure and may only be used as part of a treatment train, followed by a biotreatment measure.

MAINTENANCE CONSIDERATIONS FOR ALL TREATMENT MEASURES

- A Maintenance Agreement shall be provided.
- Maintenance Agreement shall state the parties' responsibility for maintenance and upkeep.
- Prepare a maintenance plan and submit with Maintenance Agreement. Maintenance plan templates are in Appendix H.

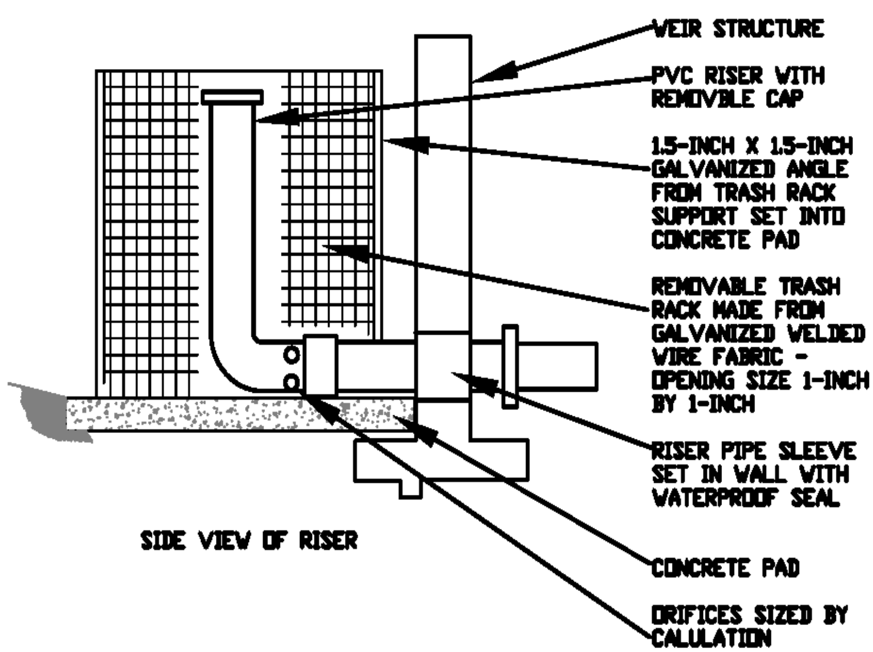


Figure 6-24: Side view of riser, extended detention basin

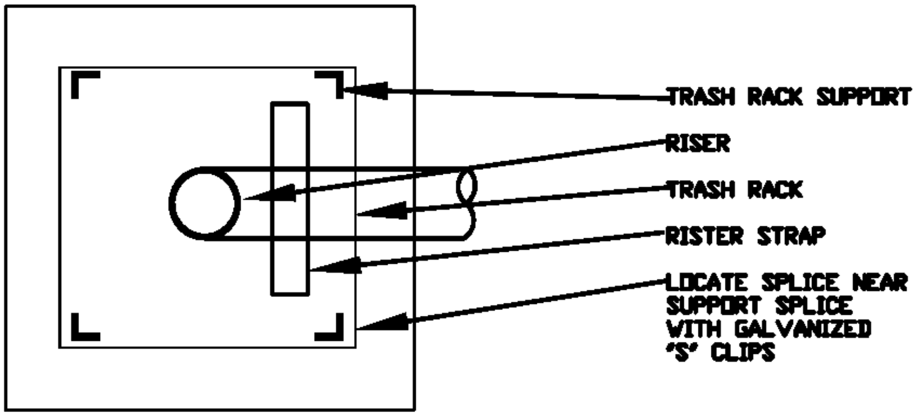


Figure 6-25: Top view of riser, extended detention basin (square design)

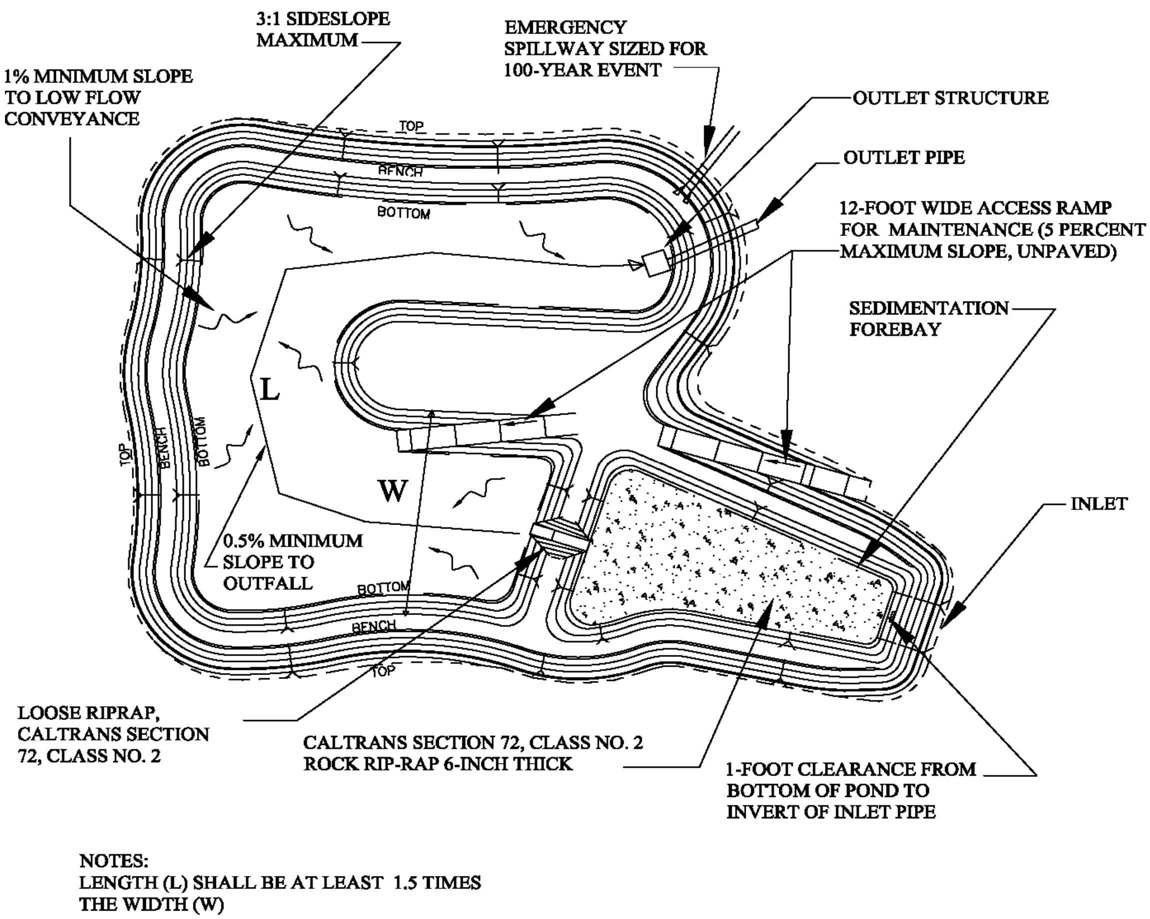


Figure 6-26: Plan View, Typical Extended Detention Basin

6.7 Pervious Paving

Figure 6-27: Parking Lot with Pervious Pavement, Emeryville

BEST USES

- Parking areas
- Common areas
- Pathways

ADVANTAGES

- Flow attenuation
- Removes fine particulates
- Reduces need for treatment

LIMITATIONS

- May clog without periodic vacuum cleaning
- Lightly trafficked areas only
- Higher installation costs

Pervious paving is used for areas with light vehicle loading and lightly trafficked areas, such as automobile parking areas. The term pervious paving describes a system comprised of a load-bearing, durable surface together with an underlying layered structure that temporarily stores water prior to infiltration or drainage to a controlled outlet. The surface is porous allowing water to infiltrate across the entire surface of the material (e.g., crushed aggregate, porous concrete or porous asphalt). Where pervious paving is underlain with pervious soil or pervious storage material sufficient to hold the Municipal Stormwater Regional Permit Provision C.3.d volume of rainfall runoff, it is not considered impervious and can function as a self-treating area.

Design and Sizing Guidelines

The design of each layer of the pavement must be determined by the likely traffic loadings and the layers' required operational life. The following criteria shall be considered:

SUBGRADE AND SITE REQUIREMENTS

- The sub-grade shall be able to sustain traffic loading without excessive deformation.
- The sub-grade shall be ungraded in-situ material with a percolation rate of 5-inches per hour, or underdrain shall be installed to remove detained flows within the pervious paving and base.
- Depth to groundwater shall be at least 10 feet from bottom of base.
- Slopes of pervious pavement should not exceed 5%, or up to 16% with underdrains. On steep slopes, provide cut-off trenches lateral to the slope to intercept, store and infiltrate drainage from the base course.

BASE LAYER

- The granular capping and base layers shall give sufficient load-bearing to provide an adequate construction platform and base for the overlying pavement layers.

- The base aggregate particles shall be selected based on strength and durability when saturated and subjected to wetting and drying.
- If the base layer is sized to hold at least the Municipal Stormwater Regional Permit Provision C.3.d volume of rainfall runoff, the area of pervious paving is not considered an impervious surface and can function as a self-treating area, as described in Section 4. 1.
- If the base layer has sufficient capacity in the void space to store the C.3.d amount of runoff for both the area of pervious paving and the area that drains to it, it is not considered an impervious surface and can function as a self-retaining area, described in Section 4.2.
- If an underdrain is used, position a minimum of 2 inches above bottom elevation of base course. To be considered a self-treating area or self-retaining area, the underdrain shall be positioned above the portion of the base layer that is sized to meet the C.3.d sizing criteria.
- Design calculations for the base shall quantify the following:
    - Type of soil, type of fill if used, permeability of base, k-values (psi/cubic inch)
    - Compressibility (clay and silt contents, organics, muck)
    - Traffic loading (in 18,000 lb. single axle loads)
    - Drainage routing of detained flows within the pervious pavement and base (infiltration through minimum 5-inch per hour sub-base into in-situ soils, or collection in underdrain if percolation rate cannot be met)

PAVEMENT MATERIALS

- The pavement materials shall not crack or suffer excessive rutting under the influence of traffic. This is controlled by the horizontal tensile stress at the base of these layers.
- Pervious pavements require a single size grading to give open voids. Materials choice is therefore a compromise considering stiffness, permeability and storage capacity.

DESIGN AND INSTALLATION

- Design shall be reviewed by the manufacturer or National Ready Mixed Concrete Association (NRMCA) (www.nrmca.org), or as directed by the municipality.
- Installation shall be by contractors familiar with pervious paving installation. Only contractors with certification from NRMCA should be considered. More information can be found at www.concreteparking.org.
- Protect area from construction traffic and excessive compaction.

Maintenance

- Maintenance plan shall be provided. Typical requirements are described in Chapter 8.

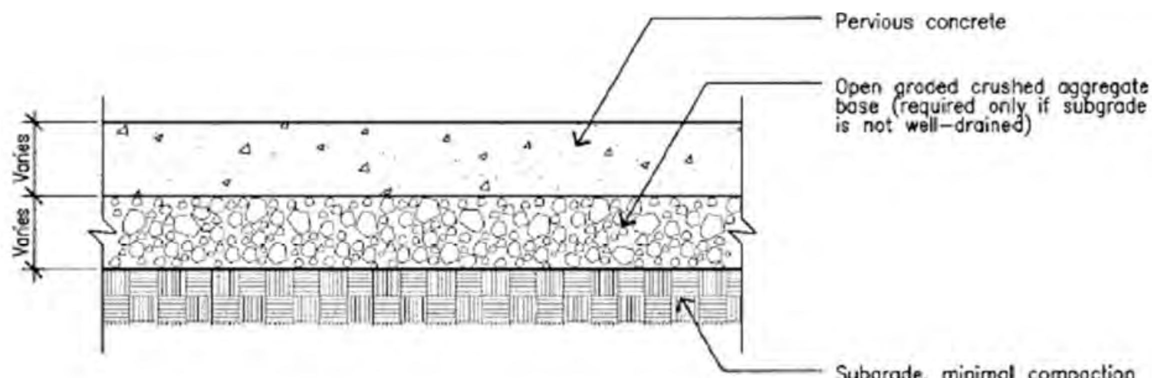


Figure 6-28: Side View of Parking Lot with Pervious Paving (Source, BASMAA, Start at the Source, 1999)

6.8 Turf Block and Permeable Joint Pavers

Figure 6-29: Turf block fire access (Source: City of Pleasanton

BEST USES
- Parking areas
- Common areas
- Lawn/landscape buffers
- Pathways

ADVANTAGES
- Flow attenuation
- Removes fine particulates
- Reduces need for treatment

LIMITATIONS
- May clog without periodic cleaning
- Weeds
- Lightly-trafficked areas only
- Higher installation costs

Turf block and permeable joint pavers are used for areas with light vehicle loading, such as automobile parking areas, and areas with little to no vehicle traffic, such as fire access lanes, and walkways. The terms turf block and permeable joint pavers describe systems comprised of a load-bearing, durable surface together with a pervious soil that temporarily stores water, with overflow conveyed to an outlet. The turf block surface is constructed of impermeable blocks separated by spaces and joints, filled with soil. The soil can be planted with turf through which water drains. Permeable joint pavers are impermeable tiles or rock plates with permeable joints to allow runoff to percolate to subsurface layers. Where subgrade soil permeability is low, an underdrain system connected to the storm drain system may be needed. Areas of turf block may be considered "self-treating areas," and may drain directly to the storm drain system if they do not receive runoff from impervious surfaces and if allowed by the local municipality. If an area of permeable joint pavers is underlain with pervious soil or pervious storage material, such as a gravel layer sufficient to hold at least the Municipal Stormwater Regional Permit Provision C.3.d volume of rainfall runoff, it is not considered an impervious surface and can function as a self-treating area, as described in Section 4. 1.

Design and Sizing Guidelines

The design of each layer of the turf block and permeable joint pavers must be determined by the likely traffic loadings and the layers' required operational life. To provide satisfactory performance, the following criteria shall be considered:

SUBGRADE AND SITE REQUIREMENTS

- The subgrade shall be able to sustain traffic loading without excessive deformation.
- An underdrain is required in clay soils.

BASE LAYER

- If the base layer is sized to hold at least the Municipal Stormwater Regional Permit Provision C.3.d volume of rainfall runoff, the area of permeable joint paving is not considered impervious and can function as a self-treating area, per Section 4.1.
- If the base layer has sufficient capacity in the void space to store the C.3.d amount of runoff for both the area of pervious paving and the area that drains to it, it is not considered an impervious surface and can function as a self-retaining area, described in Section 4.2.
- If an underdrain is used, position a minimum of 2 inches above bottom elevation of base course. To be considered a self-treating area or self-retaining area, the underdrain shall be positioned above the portion of the base layer that is sized to meet the C.3.d sizing criteria.
- Both turf block and pavers require a single size grading to give open voids. Materials choice is therefore a compromise considering stiffness, permeability and storage capacity.
- The uniformly graded single size material cannot be compacted and is liable to move when construction traffic passes over it. This effect can be reduced by the use of angular crushed rock material with a high surface friction.
- The sub-base shall be sized for strength and durability of the aggregate particles when saturated and subjected to wetting and drying. Crushed rock on geogrid fabric matrix is a typical example of turf block and pavers' sub-base. Other examples of sub-base are uncompacted soil with a sand bed to support the turf block or paver. The sub-base should be reviewed by the manufacturer of turf blocks or pavers.

PAVER MATERIALS

- The turf block or permeable joint pavers shall give sufficient load-bearing to provide an adequate support for loading.
- The paver materials should not crack or suffer excessive breakage under traffic.

CONSTRUCTION

- Protect area from construction traffic and excessive compaction.

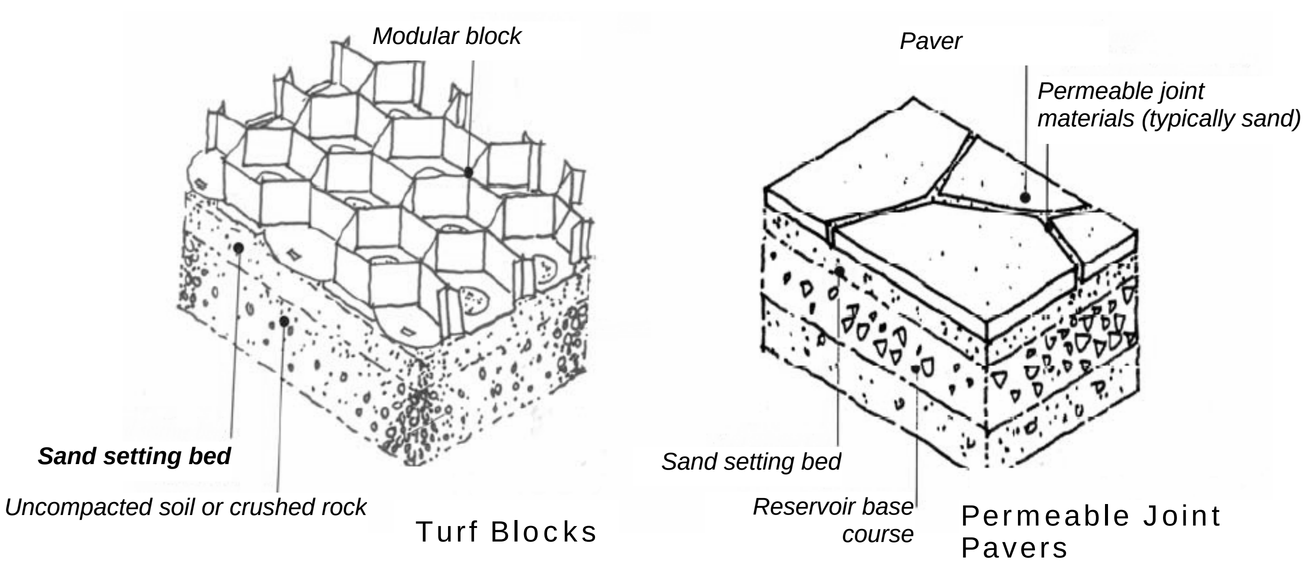


Figure 6-30: Surface and Side Views of Turf Block and Permeable Joint Pavers (Source, BASMAA. Start at the Source. 1999)

Maintenance

- A maintenance plan shall be provided. Typical maintenance requirements described in Chapter 8.

Figure 6-31: Permeable Joint Pavers at High Density Housing Project, Berkeley

6.9 Green Roofs

Figure 6-32: Extensive Green Roof in Emeryville

Best Uses

- For innovative architecture
- Urban centers

Advantages

- Minimizes roof runoff
- Reduces "heat island" effect
- Absorbs sound
- Provides bird habitat
- Longer "lifespan" than conventional roofs

Limitations

- Sloped roofs require steps
- Non-traditional design
- High installation costs

A green roof can be either ***extensive***, with a 3 to 7 inches of lightweight substrate and a few types of low-profile, low-maintenance plants, or ***intensive*** with a thicker (8 to 48 inches) substrate, more varied plantings, and a more garden-like appearance. The extensive installation at the Gap Headquarters in San Bruno (Figure 6-32), has experienced relatively few problems after nearly a decade in use. Native vegetation may be selected to provide habitat for endangered species of butterflies, as at the extensive green roof of the Academy of Sciences in San Francisco.

Design and Sizing Guidelines

- Green roofs are considered "self-treating areas" or "self-retaining areas" and may drain directly to the storm drain, if they meet the following requirements, specified in the MRP, as amended on November 28, 2011:
  - The green roof system planting media shall be sufficiently deep to provide capacity within the pore space of the media to capture 80 percent of the average annual runoff.
  - The planting media shall be sufficiently deep to support the long-term health of the vegetation selected for the green roof, as specified by the landscape architect or other knowledgeable professional.
- Extensive green roof systems contain layers of protective materials to convey water away from the roof deck. Starting from the bottom up, a waterproof membrane is installed, followed by a root barrier, a layer of insulation (optional), a drainage layer, a filter fabric for fine soils, the engineered growing medium or soil substrate, and the plant material.
- The components of intensive green roofs are generally the same as those used in extensive green roofs, with differences in depth and project-specific design application.
- Design and installation is typically completed by an established vendor.
- Follow manufacturer recommendations for slope, treatment width, and maintenance.

- Either grass or a diverse selection of other low growing, drought tolerant, native vegetation should be specified. Vegetation whose growing season corresponds to the wet season is preferred. See Appendix B for planting guidance.
- Green roof shall be free of gullies or rills.
- Irrigation is typically required.

Maintenance

- Inspection required at least semiannually. Confirm adequate irrigation for plant health.
- Fertilize and replenish growing media as specified by landscape designer and as needed for plant health. See Appendix B for alternatives to quick release fertilizers.

See www.greenroofs.com for information about and more examples of green roofs.

Figure 6-33: Extensive Green Roof at Gap Corporate Headquarters, San Bruno (William McDonough & Partners)

Figure 6-34: Intensive Green Roof at Kaiser Center, Oakland

Figure 6-35: Plants selected to support endangered butterflies (California Academy of Sciences)

6.10 Rainwater Harvesting and Use

Figure 6-36: Rainwater is collected and used for flushing toilets at Mills College, Oakland.

Best Uses

- High density residential or office towers with high toilet flushing demand.
- Park or low density development with high irrigation demand.
- Industrial use with high non-potable water demand.

Advantages

- Helps obtain LEED or other credits for green building.

Limitations

- High installation and maintenance costs.
- Low return on investment.
- Municipal permitting requirements not standardized.

Rainwater harvesting systems area engineered to store a specified volume of water with no discharge until this volume is exceeded. Storage facilities that can be used to harvest rainwater include above-ground or below-ground cisterns, open storage reservoirs (e.g., ponds and lakes), and various underground storage devices (tanks, vaults, pipes, arch spans, and proprietary storage systems). Rooftop runoff is the stormwater most often collected in harvesting/use system, because it often contains lower pollutant loads than surface runoff, and it provides accessible locations for collection. Rainwater can also be stored under hardscape elements, such as paths and walkways, by using structural plastic storage units, such as RainTank, or other proprietary storage products. Water stored in this way can be used to supplement onsite irrigation needs, typically requiring pumps to connect to the irrigation system. Rain barrels are often used in residential installations, but typically collect only 55 to 120 gallons per barrel; whereas systems that are sized to meet Provision C.3 stormwater treatment requirements typically require thousands of gallons of storage.

Uses of Harvested Water

Uses of captured water may potentially include irrigation, indoor non-potable use such as toilet flushing, industrial processing, or other uses. As indicated in Appendix J, the Harvest and Use, Infiltration and Evapotranspiration Feasibility/Infeasibility Criteria Report (Feasibility Report) identified toilet flushing as the use that is most likely to generate sufficient demand to use the C.3.d amount of runoff. The demand for indoor toilet flushing is most likely to equal to the C.3.d

6.11 Media Filter

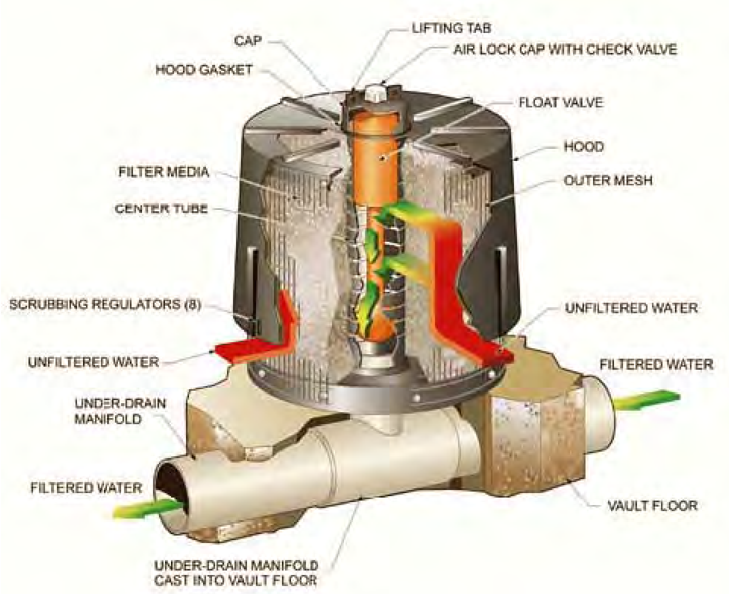


Figure 6-37: System C Filter Cartridge, Typically Used as Part of Array. Source: CONTECH Stormwater Solutions, 2006. (Note: Proprietary products shown are for general information only and are not endorsed by the Clean Water Program. An equivalent filter may be used.)

Best Uses

- "Special Projects" per Appendix K
- Limited space
- Underground
- Used following a separation unit, such as swirl concentrator

Advantages

- Less area required
- Customized media
- Customized sizing

Limitations

- No removal of trash without pre-treatment
- High installation and maintenance costs.
- Media filtration will be allowed only for some "special projects" beginning December 2011

Stormwater media filters are usually two-chambered, including a pretreatment settling basin and a filter bed filled with sand or other absorptive filtering media. As stormwater flows into the first chamber, large particles settle out, and then finer particles and other pollutants are removed as stormwater flows through the filtering media in the second chamber. There are currently three types of manufactured stormwater media filter systems. Two are similar in that they use cartridges of a standard size (filter types B and C, seen above). The cartridges are placed in vaults; the number of cartridges is a function of the design flow rate. The water flows laterally (horizontally) into the cartridge to a center well, then downward to an underdrain system. The third product (type A) is a flatbed filter, similar in appearance to sand filters.

Note: Beginning December 1, 2011, the ***use of media filters will not be allowed***, except as may be indicated in Special Projects criteria (Appendix K).

Design and Sizing Guidelines

There are generally three types of stormwater filter systems:
Filter System A:

- This system is similar in appearance to a slow-rate sand filter.
- The media is cellulose material treated to enhance its ability to remove hydrocarbons and other organic compounds. The media depth is 12 inches.
- Operates at a very high rate, at peak flows. Normal operating rates are much lower assuming that the stormwater covers the entire bed at flows less than the peak rate.

- System uses a swirl concentrator for pretreatment.
- As the media is intended to remove sediments (with attached pollutants) and organic compounds, it would not be expected to remove dissolved pollutants such as nutrients and metals unless they are complexed with the organic compounds that are removed.

Filter System B:

- Uses a simple vertical filter consisting of 3-inch diameter, 30-inch high slotted plastic pipe wrapped with fabric.
- The standard fabric has nominal openings of 10 microns. The stormwater flows into the vertical filter pipes and out through an underdrain system. Several units are placed vertically at 1-foot intervals to give the desired capacity.
- The filter bay has a typical emptying time of 12 to 24 hours.
- In a cartridge filter the media is fabric, therefore the system may not remove dissolved pollutants. It does remove pollutants attached to the sediment that is removed.

Filter System C:

- The system uses vertical cartridges in which stormwater enters radially to a center well within the filter unit, flowing downward to an underdrain system.
- Flow is controlled by a passive float valve system, which prevents water from passing through the cartridge until the water level in the vault rises to the top of the cartridge.
- Full use of the entire filter surface area and the volume of the cartridge is assured by a passive siphon mechanism as the water surface recedes below the top of the cartridge.
- A balance between hydrostatic forces assures a more or less equal flow potential across vertical face of filter surface. Filter surface receives suspended solids evenly in this system.
- Absent the float valve and siphon systems, the amount of water treated over time per unit area in a vertical filter is not constant, decreasing with the filter height; furthermore, a filter would clog unevenly.
- Restriction of the flow using orifices ensures consistent hydraulic conductivity of the cartridge as a whole by allowing the orifice, rather than the media, whose hydraulic conductivity decreases over time, to control flow.
- Manufacturers offer several media types used singly or in combination (dual- or multi-media). Total media thickness is about 7 inches. Some media, such as fabric and perlite, remove only suspended solids (with attached pollutants). Dissolved pollutants may be targeted for removal by using media consisting of compost, zeolite, and iron-infused polymer. Pretreatment occurs in an upstream unit and/or the vault within which the cartridges are located. Water quality volume or flow rate (depending on the product) is determined by local governments or sized so that 85% of annual runoff volume is treated.

All 3 types of media filter require a pretreatment system in place such as a swirl concentrator.

CONSIDERATIONS FOR PROPRIETARY SYSTEMS

- ***Consider hydraulic depth.*** Different types of manufactured treatment measures have different head losses. Your options may be limited if the site has limited hydraulic depth or other constraints.
- ***Allow for necessary field changes.*** In the planning permit application submittal, request approval to use more than one manufactured treatment measure product in the project. Format the design, details, and specifications to identify the approved, alternative

manufactured treatment measures, and include these documents in the building permit application submittal. Giving the contractor options to work with will help avoid delays.

- ***Allow design flexibility.*** Some manufactured treatment measures have the same invert elevation in and out, while some require a change in elevation between the invert and outlet. If possible, provide for a design that allows for a change in invert elevations.
- ***Consider site constraints.*** Some manufactured treatment measures that require a differential head to operate may not work in a retrofit situation, where inlet and outlet pipe elevations cannot be changed without reinstalling long lengths of existing pipe.
- ***Include sufficient information.*** Contract documents should include enough design information so that the contractor can evaluate and demonstrate that the treatment measure meets the design objectives.
- ***Avoid approval problems.*** If applicable, clarify in the design and construction documents that the contractor will be responsible for obtaining approval from the local jurisdiction for any changes that violate the approved permit plans or conditions.

MAINTENANCE CONSIDERATIONS FOR ALL TREATMENT MEASURES

- A Maintenance Agreement shall be provided.
- Maintenance Agreement shall state the parties' responsibility for maintenance and upkeep.
- Prepare a maintenance plan and submit with Maintenance Agreement. Maintenance plan templates are in Appendix H.

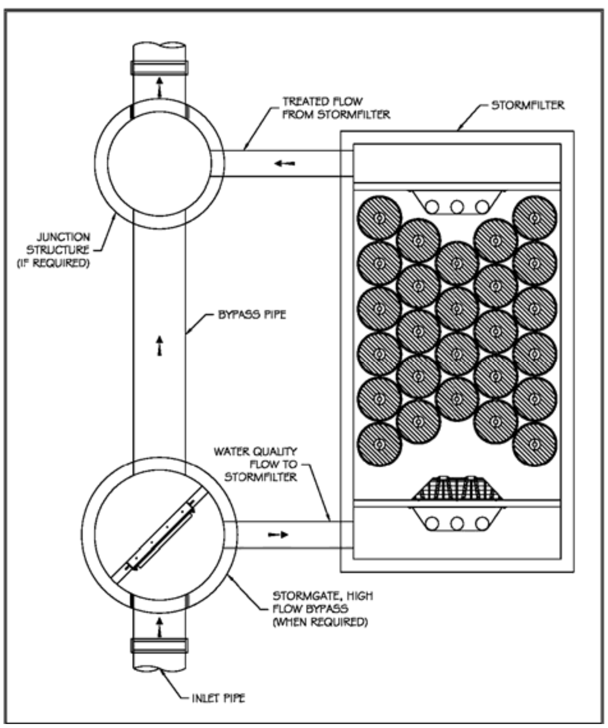


Figure 6-38: Profile View, Typical System C Filter Array. Source: CONTECH Stormwater Solutions, 2006. (Note: The proprietary media filters shown are for general information only and are not endorsed by the Clean Water Program.)

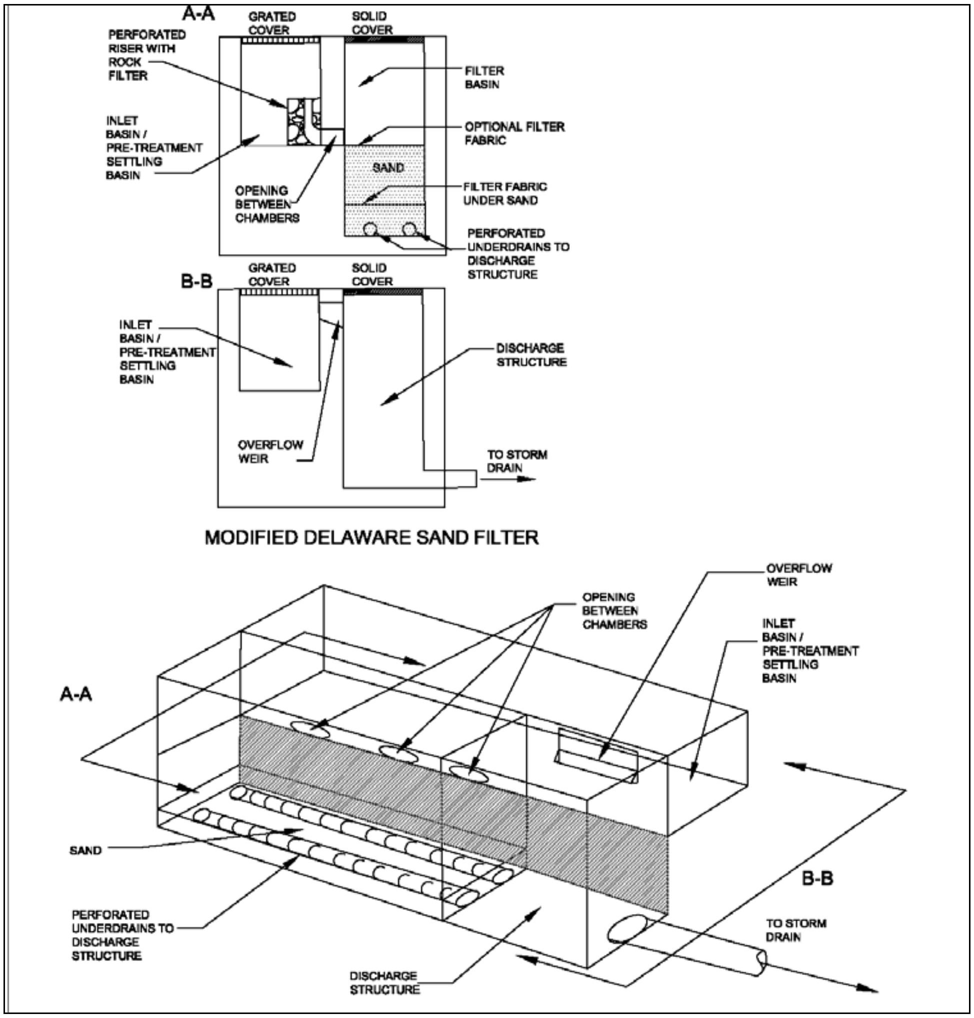


Figure 6-39: Cut Away Profile Views, System A Filter (Modified Delaware Sand Filter)

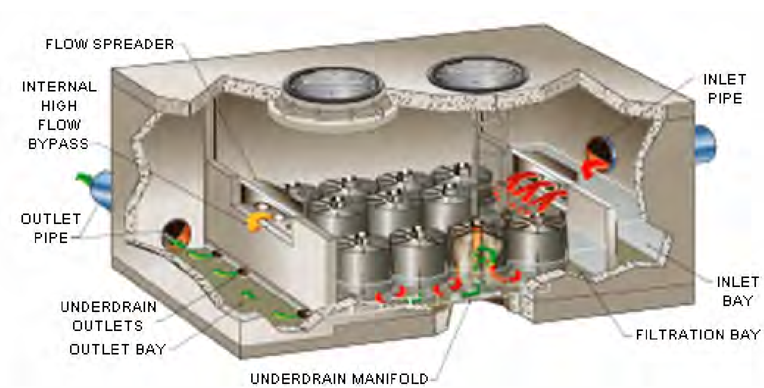


Figure 6-40: Plan View, Typical System C Filter Array. Source: CONTECH, 2006.
(Note: Proprietary media filters shown are for general information only and are not endorsed by the Clean Water Program.)

amount of stormwater in high rise residential or office projects, and in schools. Irrigation demand may equal the C.3.d amount of runoff in projects with a very high percentage of landscaping.

System Components

Rainwater harvesting systems typically include several components: (1) methods to divert stormwater runoff to the storage device, (2) an overflow for when the storage device is full, and (3) a distribution system to get the water to where it is intended to be used. Filtration and treatment systems are typically required for indoor uses of harvested rainwater (see Table 6-2).

LEAF SCREENS, FIRST-FLUSH DIVERTERS, AND ROOF WASHERS

These features may be installed to remove debris and dust from the captured rainwater before it goes to the tank. The initial rainfall of any storm often picks up the most pollutants from dust, bird droppings and other particles that accumulate on the roof surface between rain events. Leaf screens remove larger debris, such as leaves, twigs, and blooms that fall on the roof. A first-flush diverter routes the first flow of water from the catchment surface away from the storage tank to remove accumulated smaller contaminants, such as dust, pollen, and bird and rodent feces. A roof washer may be placed just ahead of the storage tank and filters small debris for systems using drip irrigation. Roof washers consist of a tank, usually between 30- and 50-gallon capacity, with leaf strainers and a filter.

TREATMENT METHODS

The Texas Manual on Rainwater Harvesting (3rd Edition, 2006) identifies two methods of treatment used in rainwater harvesting systems for indoor use: chlorine and UV light. Chlorine has a longer history of use in the US, and is still reported to be used by rainwater harvesters, but it has drawbacks. Chlorine combines with decaying organic matter in water to form trihalomethanes, a by-product that has been found to cause cancer in laboratory rats; some users may find the taste and smell of chlorine objectionable; and chlorine does not kill *Giardia* or *Cryptosporidium*, which are cysts protected by their outer shells. ***UV light has more recently become common practice*** in U.S. utilities. Bacteria, virus, and cysts are killed by exposure to UV light. The water must go through sediment filtration before the ultraviolet light treatment because pathogens can be shadowed from the UV light by suspended particles in the water. In water with very high bacterial counts, some bacteria will be shielded by the bodies of other bacteria cells. UV lights are benign: they disinfect without leaving behind any disinfection by-products, and they use minimal power for operation.

Table 6-2
Typical Water Quality Guidelines from the Texas Rainwater Harvesting Manual

Use	Minimum Water Quality Guidelines	Suggested Treatment Guidance
Non-potable indoor uses	▪ Total coliforms < 500 cfu per 100 mL ▪ Fecal coliforms < 100 cfu per 100 mL	▪ Pre-filtration – first flush diverter ▪ Cartridge filtration – 5 micron sediment filter ▪ Disinfection – chlorination with household bleach or UV disinfection
Outdoor uses	N/A	▪ Pre-filtration – first flush diverter

Source: Low Impact Development Manual for Southern California, Low Impact Development Center, 2010, which, in turn, cites the Texas Rainwater Harvesting Manual for this information.

Design and Sizing Guidelines

HYDRAULIC SIZING

- If a rainwater harvesting system will be designed to meet Provision C.3 stormwater requirements, there must be sufficient demand to use 80 percent of the average annual rainfall runoff, as specified in Provision C.3.d.
- If the project's completed Rainwater Harvesting Worksheet (or other project-specific calculation) indicates that there is sufficient demand, size the cistern (or other storage device) to achieve the maximum drawdown time indicated in Table 9 of the Feasibility Report (included in Appendix J).

DESIGN GUIDELINES FOR ALL SYSTEMS

- Equip water storage facilities covers with tight seals, to reduce mosquito-breeding risk. Follow mosquito control guidance in Appendix G.
- Water storage systems in proximity to the building may be subject to approval by the building official. The use of waterproofing as defined in the building code may be required for some systems, and the municipality may require periodic inspection. Check with municipal staff for the local jurisdiction's requirements.
- Do not install rainwater storage devices in locations where geotechnical/stability concerns, such as a slope above 10%, may prohibit the storage of large quantities of water.
- Provide separate piping without direct connection to potable water piping. Dedicated piping should be color coded and labeled as harvested rainwater, not for consumption. Faucets supplied with non-potable rainwater should include signage identifying the water source as non-potable and not for consumption.\
- The harvesting system must not be connected to the potable water system at any time.
- When make-up water is provided to the harvest/reuse system from the municipal system, prevent cross contamination by providing a backflow prevention assembly on the potable water supply line, an air gap, or both, to prevent harvested water from entering the potable supply. Contact local water system authorities to determine specific requirements.

DESIGN GUIDELINES FOR INDOOR USE

- Avoid harvesting water for indoor use from roofs with architectural copper, which may discolor porcelain.
- Provide filtration of rainwater harvested for indoor non-potable use, as required by the plumbing code and any municipality-specific requirements.

DESIGN GUIDELINES FOR IRRIGATION USE

- Water diverted by a first flush diverter may be routed to a landscaped area large enough to accommodate the volume, or a hydraulically-sized treatment measure.
- First flush diverters shall be installed in such a way that they will be easily accessible for regular maintenance.
- Do not direct to food-producing gardens rainwater harvested from roofs with wood shingles or shakes (due to the leaching of compounds), asphalt shingles, tar, lead, or other materials that may adversely affect food for human consumption.

MAINTENANCE CONSIDERATIONS FOR ALL TREATMENT MEASURES

- A Maintenance Agreement shall be provided and shall state the parties' responsibility for maintenance and upkeep.
- Prepare a maintenance plan and submit with Maintenance Agreement.

Chapter

7

Hydromodification Management Measures

This Chapter summarizes the requirements for controlling erosive flows from development projects.

7.1 Why Require Hydromodification Management?

Changes in the timing and volume of runoff from a site are known as “hydrograph modification” or “hydromodification”. When a site is developed, much of the rainwater can no longer infiltrate into the soils, so it flows offsite at ***faster rates and greater volumes***. As a result, erosive levels of flow occur more frequently and for longer periods of time in creeks and channels downstream of the project. Hydrograph modification is illustrated in Figure 7-1, which shows the stormwater peak discharges after rainstorms in an urban watershed (the red, or dark, line) and a less developed (the yellow, or light, line). The axes indicate the volume of water discharged, and the time over which it is discharged.

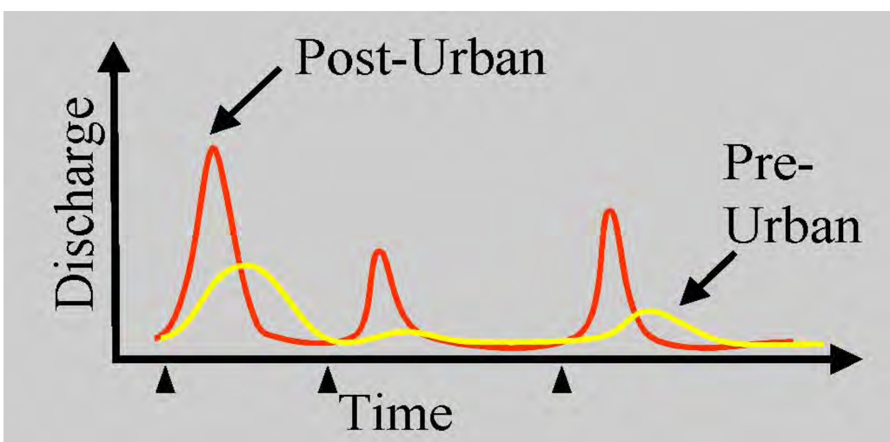


Figure 7-1: Stormwater Peak Discharges in Urban (Red) and Less Developed (Yellow) Watersheds (Source: NEMO-California Partnership, No Date)

In watersheds with large amounts of impervious surface, the larger volumes and faster rates of flow, with extended durations of flows that cause erosion, often cause natural creeks or earthen channels to erode, as the channel enlarges in response to the increased flows. Problems from this additional erosion often include property damage, degradation of stream habitat and loss of water quality, and have not been addressed by traditional detention designs. Figures 7-2 and 7-3 illustrate the effect of increasing urbanization on stormwater volumes.

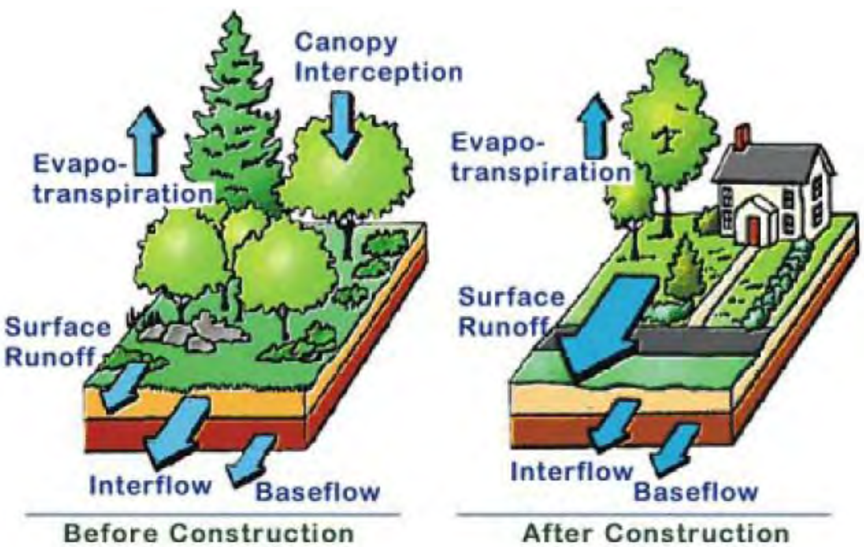


Figure 7-2: Effects of Urbanization on the Local Hydrologic Cycle (Source: 2000 Maryland Stormwater Design Manual)

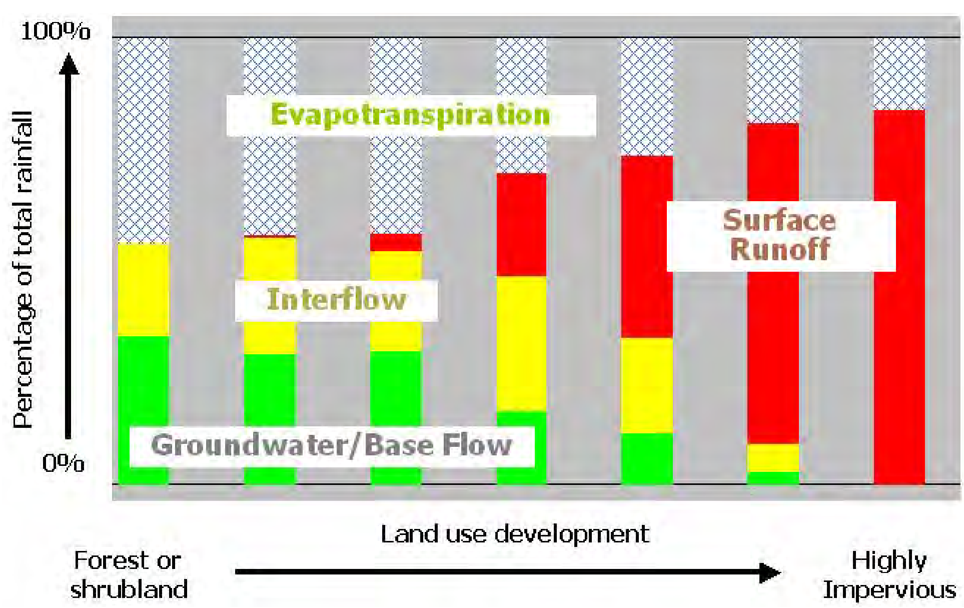


Figure 7-3. Variation in rainfall contribution to different components of the hydrological cycle for areas with different intensity of urban development. (Chart used by permission of Clear Creek Solutions.)

Since 2007, new hydromodification management (HM) techniques have been required in areas across the San Francisco Bay Area that are susceptible to hydromodification. These techniques focus on ***retaining, detaining or infiltrating runoff*** and matching post-project flows and durations to pre-project patterns for a specified range of smaller, more frequent rain events, to prevent increases in channel erosion downstream. Within Alameda County, a simple map-based approach is used to determine which parts of the drainage network are susceptible to hydromodification impacts. Projects that meet certain criteria, and from which runoff passes through the susceptible areas, are be required to incorporate one or more HM measures in the design in order to reduce erosive flows from a wide range of runoff conditions.

Hydromodification management (HM) techniques focus on ***retaining, detaining or infiltrating runoff.***

7.2 Which Projects Need to Implement HM?

Unless it is a single family home that is not part of a larger of development, your project will be required to comply with the HM requirements if it meets the following applicability criteria:

- The project ***creates and/or replaces one acre or more of impervious surface***,
- The project ***will increase impervious surface*** over pre-project conditions, AND
- The project is ***located in a susceptible area***, as shown on the default susceptibility map.

Appendix I shows a schematic view of a portion of the hydromodification susceptibility map. The full map may be downloaded from the Clean Water Program website in an interactive format that enables zooming to a closer view of the project vicinity with local streets. Note that project sites draining to earthen flood control channels are not automatically exempt from HM requirements.

Please note that projects located in susceptible areas are encouraged to include hydrologic source control measures for HM if they are likely to cause hydrograph changes, ***even if they create and/or replace less than one acre of impervious surface.***

7.3 Hydromodification Management (HM) Measures

Hydromodification management (HM) measures can be grouped into three types:

- ***Site design and hydrologic source control measures***, which are generally distributed throughout a project site. These types of measures minimize hydrological changes caused by development beginning with the point where rainfall initially meets the ground. Examples include minimizing impervious area, disconnecting roof leaders and providing localized detention – which also helps reduce stormwater pollution.
- ***On-site structural HM measures*** that manage excess runoff from the site after hydrologic source control measures are applied. These ***"end-of-pipe" measures*** mitigate the effects of hydrograph changes. Stormwater is temporarily detained, and then the runoff is gradually discharged to a natural channel at a rate calculated to avoid adverse effects. Examples include extended detention basins, wet ponds and constructed

wetlands. Please note that there is a difference between the design approach for sizing measures to remove pollutants from stormwater and the approach for designing HM measures to prevent an increase in the potential for creek bank erosion. The treatment of stormwater pollutants targets capture of 80% of average runoff volume, which means that treatment measures will be bypassed every one to two years. Structural HM measures must be sized for ***flow duration control for frequent, small runoff events*** (with average occurrence ranging from less than two-years to approximately ten-years). The structural HM measures are sized to control the statistical duration of a wide range of flow levels under simulated runoff conditions. Depending on pre-project and post-project conditions, the required detention volume is likely to be greater than the capture volume required for treatment.

> Structural HM measures must be sized to control the flow and duration of stormwater runoff according to a ***Flow Duration Control*** standard, which is often greater than size requirements for volume-based treatment.

- ***In-stream or restorative measures*** that modify susceptible watercourses to withstand projected increases in runoff flows and durations without increasing erosion or other impacts to beneficial uses. In-stream measures are more complicated to use than the hydrologic source control and end-of-pipe measures, and are ***best suited for creeks or channels that have already received impacts*** from previous development and have only localized channel instability. Examples include biostabilization techniques using roots of live vegetation roots to stabilize banks and localized structural measures such as rock weirs, boulder clusters or deflectors. These measures will not automatically provide HM protection for channel reaches farther downstream and may require longer planning timelines and cooperation among multiple jurisdictions compared to on-site measures.

7.4 Requirements for Hydromodification Management

For projects subject to HM requirements, consider HM at every stage of project development and incorporate the step-by-step instructions for C.3 submittals, provided in Chapter 3. The most effective use of land and resources may require combining measures from all three categories described above. In general, the strategy for designing HM measures should :

- ***Start with site design*** to minimize the amount of runoff to be managed (see Planning Steps 2 & 3 in Chapter 3).
- Where possible, ***maximize infiltration*** to further reduce detention requirements. Note that infiltration is limited by site constraints such as slope stability concerns, low-permeability soils or groundwater protection constraints.
- Use ***structural HM measures*** to detain the remaining calculated runoff from the site enough to ***control its release*** in a way that meets the remaining runoff design requirements. This may be accomplished with a measure that also provides volume-based treatment, such as an extended detention basin. For some project locations, off-site options may be available to reduce or eliminate the need for onsite detention.

7.4.1 Flow Duration Control

Flow Duration Control (FDC) differs from traditional "design storm" approaches used to design detention facilities for flood control or water quality treatment. Instead of specifying static holding times for one or a few discrete events, the Flow Duration standard manages runoff discharge over the full range of runoff flow levels predicted through continuous hydrologic simulation modeling, based on a long-term precipitation record. Flow Duration Control requires that the increase in surface runoff resulting from new impervious surfaces be ***retained on-site with gradual discharge*** either to groundwater through infiltration, losses by evapotranspiration, and/or discharge to the downstream watercourse at a level below the critical flow that causes creek channel erosion. ***Critical flow,*** or Qc**,** is the lower threshold of in-stream flows that contribute to sediment erosion and sediment transport or effective work. The duration of channel flows below Qc may be increased indefinitely without significant contribution to hydromodification impacts.

> The duration of channel flows below the ***"critical flow"*** may be increased indefinitely without significant contribution to hydromodification impacts.

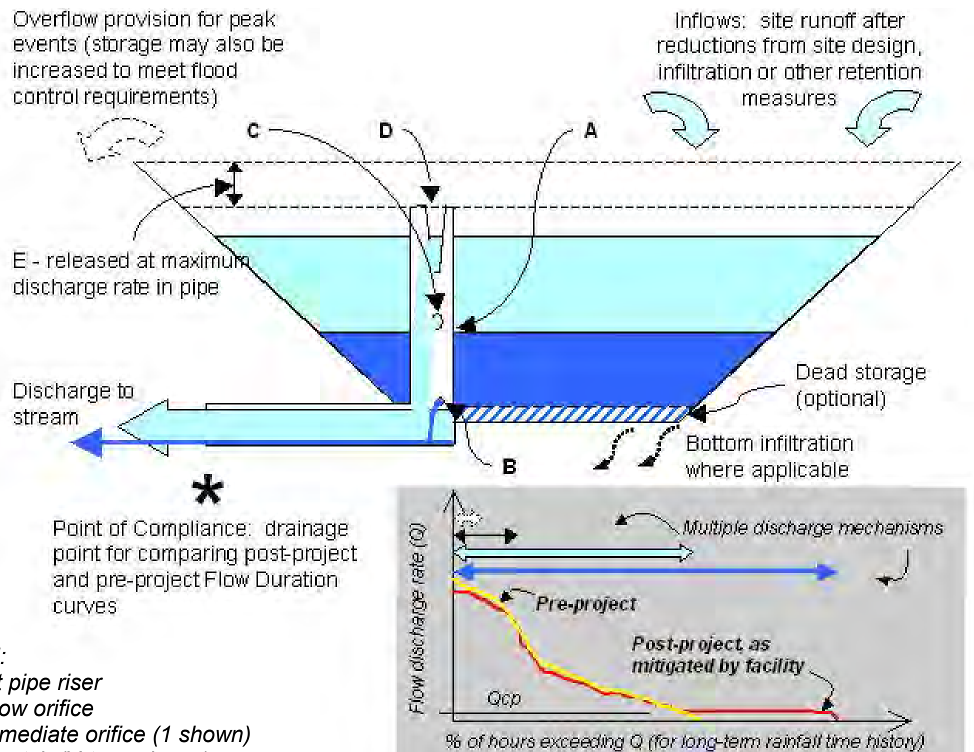
7.4.2 Application of Flow Duration Control to Project Areas

The Flow Duration approach involves a continuous model that applies a time series of at least 20 years of rainfall records to a watershed area or project site to generate a simulated stormwater runoff record based on two sets of inputs, one representing future development and the other representing pre-project conditions. The 20-year precipitation record is the minimum length necessary to capture the range of runoff conditions that are cumulatively responsible for most of the erosion and sediment transport in the watershed, primarily flow levels that would recur at average intervals of 10 years or less in the pre-project condition. The design objective is to preserve the pre-project cumulative frequency distribution of flow durations and sizes under post-project flows. This is done with a combination of site design, infiltration and detention. Typically the post-project increase in surface runoff volume is routed through a ***flow duration control pond*** or other structure that detains a certain portion of the increased runoff and discharges it through a ***specialized outlet structure*** (see Figure 7-4).

The flow duration basin, tank or vault is designed conceptually to incorporate multiple pools that are filled with different frequencies and discharge at different rates. The low-flow pool is the bottom level designed to capture and retain small to moderate size storms, the initial portions of larger storms, and dry weather flows. These flows are discharged through the lowest orifice which allows continuous ***discharge below the critical flow rate*** for a project (Qcp). Successively higher-flow pools store and release higher but less frequent flows through other orifices or graded weir notches to approximate the pre-project runoff durations. In practice the multiple pools are usually integrated into a single detention basin, tank or vault that works as a unit with the specialized outlet structure. Matching the pre-project flow durations is achieved through fine-tuning of the number, heights and dimensions of orifices or weir notches, as well as depth and volume of the basin, tank or vault.

> Flow Duration facilities are subject to ***Operations and Maintenance*** reporting and verification requirements similar to those for numerically sized treatment measures.

As shown in the example chart of Figure 7-4, the post-project flow duration curve (red, or dark line) is reduced by the facility to remain ***at or below the pre-project curve*** (yellow, or light line), except for flows less than Qcp. Minor exceedances are permissible at a limited number of higher flows since at other flow levels the post-project duration is actually less than the pre-project condition.



Legend:
A-outlet pipe riser
B-low flow orifice
C- intermediate orifice (1 shown)
D-weir notch (V-type shown)
E-freeboard above riser (typically 1 foot)

Figure 7-4: Schematic flow duration pond and flow duration curves matched by varying discharge rates according to detained volume.

If feasible, ***combining flow duration and water quality treatment*** into a single facility reduces the overall land requirements for stormwater management. ***Adequate maintenance*** of the low-flow orifice or notch is critical to proper performance. The outlet may be in a protective enclosure to reduce risk of clogging. Please note that Flow Duration facilities are subject to Operations and Maintenance verification requirements similar to those for numerically sized treatment measures.

7.4.3 Bay Area Hydrology Model (BAHM)

To facilitate the simulation modeling aspect of FDC for project proponents and their engineers, the Clean Water Program collaborated with the Santa Clara and San Mateo Counties' stormwater programs to develop a Bay Area Hydrology Model ***software package*** that is adapted from Version 3 of the Western Washington Hydrology Model (WWHM) developed by Clear Creek Solutions for the State of Washington Department of Ecology (WDOE). The

WWHM was specifically developed to help engineers design facilities to meet a Flow Duration Control standard for development projects.

The BAHM is available for downloading at www.bayareahydrologymodel.com, and it includes:

- Databases to automatically assign default ***rainfall conditions*** for a project location selected within the County boundary.
- A user interface for developing a ***schematic drainage model*** of the project site, with forms for entering areas of land use or impervious surface for multiple sub-basins.
- Continuous simulation modeling of ***pre-project and post-project runoff*** from the site using actual long-term rainfall records appropriately scaled for the project location.
- A design module for sizing a ***FDC detention facility*** and designing the discharge structure to meet the Flow Duration standard for matching post-project and pre-project duration-frequency curves. Pre-project and post-project runoff are compared at a "point of compliance" selected by the designer, usually near the point where runoff leaves the project area.
- Options to check facility sizing for ***volume-based treatment***, and incorporate runoff reductions attributable to some common hydrologic source control measures.
- Standardized output ***report files*** that can be saved in Word format, and include all information about data inputs, model runs, facility design, and summary of the hydrological statistics showing the compliance of post-project flow duration curves with the Flow Duration standard. Project input and output data can also be saved in Excel and other formats for other uses.

Training courses on using the BAHM are offered periodically. For more information, please visit www.bayareahydrologymodel.com.

7.5 Area-Specific HM Provisions

Individual municipalities may have special policies or ordinances for creek protection applicable in all or part of their jurisdictions. ***Contact the municipal staff from your jurisdiction*** to identify any special local provisions that may encourage or affect specific forms of HM implementation. Examples of area-specific HM provisions can include:

> Individual municipalities may have special policies or ordinances for ***creek protection*** applicable in all or part of their jurisdictions.

- Watershed-based land-use planning measures, such as creek buffers, which may be incorporated in local General Plans, zoning codes or watercourse ordinances.
- Special permitting provisions for project design and review of projects on streamside properties.
- Specific plans for regional HM measures or in-stream restoration projects.

7.6 When On-site HM is Impracticable

Under specific conditions, the MRP allows projects to meet HM requirements by providing for or contributing financially to an off-site alternative HM project.

7.6.1 Determining Impracticability

In order to use an off-site alternative HM project, you would need to demonstrate the following:

- Due to on site conditions (such as extreme space limitations) the ***total cost to comply with both HM and stormwater treatment requirements*** exceeds two percent of the project construction cost, excluding land costs. (When calculating costs of HM and stormwater treatment measures, do NOT include land costs, soil disposal fees, hauling, contaminated soil testing, mitigation, disposal, or other normal site enhancement costs such as landscaping or grading that are required for other development purposes.)
- There is ***no available regional HM measure*** to which runoff from your project can be directed. A regional HM measure is considered available if there is a planned location from the regional HM measure AND if an appropriate funding mechanism for the regional HM measure is in place by the time of your project's construction.
- Meeting the HM requirements by constructing ***an in-stream measure is not practicable***. An in-stream measure is considered practicable if an in-stream measure for your project's watershed is planned, and an appropriate funding mechanism for the in-stream measure is in place by the time of project construction.

7.6.2 Requirements for Using an Alternative HM Project

If you have demonstrated that on-site HM is impracticable for your project, you will need to implement the following requirements to use an alternative HM project.

- Include site designs in your project that ***provide hydrologic source control***. Examples include minimizing impervious area, disconnecting roof leaders and providing localized detention.
- Include in your project stormwater treatment measures that collectively ***minimize, slow and detain runoff*** to the maximum extent practicable. (This generally includes bioretention areas, vegetated swales, flow-through planters, and other stormwater treatment measures that filter runoff through soil or other media.)
- ***Contribute financially*** to an alternative HM project, such as a stormwater treatment retrofit, HM retrofit, regional HM control, or in-stream measure that is not otherwise required by the Water Board or other regulatory agency. The contribution shall consist of the difference between two percent of the project construction costs and the cost of the treatment measures at the site (based on calculations described in Section 7.6.1).

Figure 7-5: Draining roof runoff to a landscaped area is an example of hydrologic source control.

Chapter

8

Operation and Maintenance

This Chapter summarizes the operation and maintenance requirements for stormwater treatment and structural hydromodification management measures.

8.1 Summary of O&M Requirements

Maintenance is essential for assuring that stormwater treatment and structural hydromodification management (HM) measures continue to function effectively and do not cause flooding, provide habitat for mosquitoes, or otherwise become a nuisance. The maintenance requirements described in this chapter apply to stormwater treatment measures and structural HM measures included in your project. The operation and maintenance (O&M) process can be organized into five phases, as described below:

- Determining ownership and maintenance responsibility,
- Identifying maintenance requirements when selecting treatment measures,
- Preparing the maintenance plan and other documentation,
- Executing a maintenance agreement or other maintenance assurance, and
- Ongoing inspections and maintenance.

O&M requirements apply to stormwater treatment AND HM measures.

8.1.1. Responsibility for Maintenance

The responsibility for the maintenance of stormwater treatment and structural HM measures ***belongs to the project applicant and/or property owner*** unless other specific arrangements have been made. Ownership and maintenance responsibility for stormwater treatment measures and structural HM measures should be considered at the earliest stages of project planning, typically at the pre-application meeting with municipal staff. The municipal stormwater permit also requires that the project applicant provide a signed statement accepting responsibility for maintenance until this responsibility is legally transferred, as well as ensuring access to municipal, Water Board, and Alameda County Mosquito Abatement District or Vector Control District staff.

8.1.2 Considerations When Selecting Treatment Measures

CONSIDER OPERATION AND MAINTENANCE

When determining which types of treatment measures to incorporate into project plans, be mindful of how maintenance intensive they are. Study the operation manual for any manufactured, proprietary system. Treatment measures must be maintained so that they continue to treat stormwater runoff effectively ***throughout the life of the project*** and do not provide habitat for mosquito breeding. Adequate funds must be allocated to support long-term site maintenance. Manufactured, proprietary systems tend to clog easily and therefore require frequent maintenance to ensure that they operate as intended and do not hold standing water. A properly designed and established bioretention area, by contrast, may require little maintenance beyond the typical requirements for areas of landscaping.

The party responsible for maintenance will also be required to ***dispose of accumulated residuals properly.*** Residuals are defined as trash, oil and grease, filter media and fine sediments that are collected from treatment measures that may or may not be contaminated. At present, research generally indicates that residuals are not hazardous wastes and as such, after dewatering, property owners can generally disposed of residuals in the same way they would dispose of any uncontaminated soil.

The USEPA Fact Sheet titled Storm Water O&M Fact Sheet: Handling and Disposal of Residuals (www.epa.gov/npdes/pubs/handdisp.pdf) provides useful information to help property owners dispose of residuals properly. The fact sheet describes the properties of stormwater residuals, O&M requirements for specific types of treatment measures, key elements for a residual handling and disposal program, and specific information on residual disposal from case studies. Two landfills in Alameda County accept sediment ("soil"), contaminated or otherwise:

- Altamont Landfill and Resource Recovery, 1040 Altamont Pass Road, Livermore, (510) 430-8509
- Vasco Road Sanitary Landfill, 4001 N. Vasco Road, Livermore, (661) 257-3655.

> Except for treatment measures designed to hold permanent pools of standing water, treatment measures should ***drain completely within five days*** to suppress mosquito production.

Alternatively, property owners may choose to contract with the treatment device manufacturer to maintain their treatment measures. Services typically provided include inspection, maintenance, handling and disposal of all residuals.

CONTROL MOSQUITOES

When selecting and installing stormwater treatment devices, you will need to consider the various environmental, construction, and local factors that may influence mosquito breeding. With the exception of certain treatment measures designed to hold permanent pools of standing water, ***treatment measures should drain completely within five days*** to effectively suppress mosquito production. The Clean Water Program has prepared a Vector Control Plan that includes mosquito control design guidance and maintenance guidance for treatment measures, which focus on mosquito control. This guidance is included in Appendix G.

CONSIDER ACCESS

The maintenance agreement for your project will need to guarantee access permission for local municipality staff, the Alameda County Mosquito Abatement District and Water Board staff to enter the property to verify that maintenance is being conducted in accordance with the maintenance plan, throughout the life of the project. Make sure stormwater treatment and structural HM measures are ***readily accessible to the inspectors***, and contact municipal staff to determine whether easements will be needed. Stormwater treatment and structural HM measures must also be accessible to equipment needed to maintain them. Maintenance needs vary by the type of treatment measure that is used. Review the maintenance requirements described in Section 8.2 to identify the accessibility needs for maintenance equipment. By nature, it is more difficult to provide adequate access for below-ground treatment measures than above-ground treatment measures.

8.1.3 Documentation Required with Permit Application

As part of the building permit application, project applicants typically need to prepare and submit the documents listed below. ***Check with the local jurisdiction*** for exact requirements.

- A legible conceptual plan of the site, clearly showing the locations of stormwater treatment measures. Letter-sized plans are preferred; legal-sized plans may be accepted.
- Detailed maintenance plan for storm water treatment and structural HM measures, including inspection checklists, as appropriate.
- A standard treatment measure O&M report form, to be attached to a maintenance agreement, or other maintenance assurance.

Please note that requirements may vary from one jurisdiction to another. Ask the staff from the local municipality if there are any additional requirements. Appendix H includes templates to assist project applicants in preparing their standard treatment measure O&M report form and maintenance plan. Guidance on preparing these documents is provided in Section 8.2.

8.1.4 Maintenance Agreement or Other Maintenance Assurance

Where a property owner is responsible for maintenance, the property owner is required to enter into a maintenance agreement with the municipality to ensure long-term maintenance of treatment and structural HM measures. The agreement will be ***recorded against the property*** to run with the title of the land. Contact your local jurisdiction to obtain a copy of its standard maintenance agreement. The maintenance agreements require property owners to conduct maintenance inspections of all stormwater treatment measures, and – depending on the municipality – may require the annual submittal of a Standard Treatment Operation and Maintenance Inspection Report form.

For residential properties where the stormwater treatment measures are located within a common area that will be maintained by a homeowner's association, language regarding the responsibility for maintenance must be included in the project's conditions, covenants and restrictions (CC&Rs). Printed educational materials regarding on-site stormwater controls are typically required to be included with the first, and any subsequent, deed transfer. The educational materials typically include the following information:

- Explain the post-construction stormwater controls requirements;

- Provide information on what stormwater controls are present;
- Describe the need for maintenance;
- Explain how necessary maintenance can be performed; and
- For the initial deed transfer, describe the assistance that the project applicant can provide.

If stormwater treatment measures are proposed to be located in a public area for transfer to the municipality, these treatment measures must meet the design guidelines specified in Chapter 6 and shall remain the property owner's responsibility for maintenance until the treatment measures are accepted for transfer.

8.1.5 Ongoing Inspections and Maintenance

After the maintenance agreement is executed, or the municipality approves other maintenance assurance such as CC&Rs, the party responsible for maintenance begins to implement the maintenance plan. Inspection reports are submitted to the municipality as required by the maintenance agreement, or other maintenance assurance.

> The municipality, Water Board and Mosquito Abatement District staff may conduct ***O&M verification inspections*** to make sure that treatment and HM measures are maintained.

The municipality, Water Board and Alameda County Mosquito Abatement District may conduct ***operation and maintenance verification inspections*** to make sure that stormwater treatment measures are being maintained. In the event adequate maintenance is not conducted, the municipality will take necessary steps to restore the treatment measures to good working order. The property owner will be responsible for reimbursing the municipality for expenditures associated with restoring the treatment measures to good working order.

8.2 Preparing Maintenance-Related Documents

This section provides instructions for preparing the following documents that will typically be required as parts of the building permit application, if your project includes stormwater treatment measures and/or structural HM measures:

- A standard treatment measure O&M report form
- A maintenance plan, including a schedule of maintenance activities.

8.2.1 Standard Treatment Measure O&M Report Form

The municipality may require the property owner, or other responsible party, to submit an annual report summarizing the maintenance and inspections of treatment measures included in the project. To standardize and simplify the reporting process, the property owner submits a "Standard Treatment Measure O&M Report Form" with the building permit application, and the municipality includes the report form as an Exhibit to the maintenance agreement. After the agreement is executed, the property owner, or other responsible party, uses this form to prepare the annual report, which is typically submitted by December 31 of each calendar year.

When submitting the completed report form each year, the responsible party will typically be required to attach the inspection forms that were completed during that calendar year.

To help you prepare your Standard Treatment Measure O&M Report Form, a template is included in Appendix H. ***Check with the local jurisdiction*** for an electronic version of the template.

When using the template to prepare your report form, please insert project-specific information where you find highlighted prompts such as the following:

[[== insert name of property owner/responsible party ==]]

8.2.2 Maintenance Plan

The maintenance plan must be sufficiently detailed to demonstrate to the municipality that stormwater treatment measures and/or structural HM measures will receive ***adequate inspections and maintenance*** to continue functioning as designed over the life of the project. A maintenance plan typically includes the following elements:

- Contact information for the property owner or other responsible party.
- Project address and, if required, the Assessors Parcel Number and directions to the site.
- Identification of the number, type and location of all stormwater treatment/structural HM measures on the site.
- A list of specific, routine maintenance tasks that will be conducted, and the intervals at which they are conducted. (For example, "Inspect treatment measure once a month, using the attached checklist.")
- An inspection checklist, specific to the treatment/HM measure(s) included in your project, which indicates the items that will be reviewed during regular maintenance inspections. You will typically be required to submit completed inspection forms as part of the annual Stormwater Treatment Measure O&M Report, as described in Section 8.2.1.

The following materials are available to help you prepare your maintenance plan:

- Maintenance plan templates included in Appendix H. Electronic versions of the templates are available at www.cleanwaterprogram.org (Click on "Businesses," then "Development Related Issues," and go to Appendix H of the C.3 Technical Guidance.
- A list of common maintenance concerns for the frequently used stormwater treatment measures, provided below.

Maintenance plan templates are provided, in Appendix H, for commonly-used stormwater treatment measures.

When using a template to prepare your maintenance plan, please insert project-specific information where you find prompts such as the following: [[== insert name of property owner/responsible party ==]]. Each template includes sample inspection checklists. If your project includes different treatment/HM measures, you may also refer to the ***treatment measure-specific maintenance information*** presented in the following paragraphs.

BIORETENTION AREAS[1] – COMMON MAINTENANCE CONCERNS:

The primary maintenance requirement for bioretention areas is the regular inspection and repair or replacement of the treatment measure's components. Generally, the level of effort is similar to the routine, periodic maintenance of any landscaped area.

- Conduct monthly inspections as follows:
  - Inspect bioretention area for obstructions and trash.
  - Inspect bioretention area for ponded water. If ponded water does not drain within five days, remove surface soils and replace with sand. If mosquito larvae are observed, contact the Alameda County Mosquito Abatement District at 510/783-7744. (In Albany, contact the Alameda County Vector Control District, at 510/567-6800.)
  - Inspect inlets for channels, exposure of soils, or other evidence of erosion. Clear any obstructions and remove any accumulation of sediment.
- Conduct a biannual (twice yearly) evaluation of the health of any plants, and remove any dead or diseased vegetation.
- Treat diseased vegetation, as needed, using preventative and low-toxic measures to the extent possible, and replace any dead plants.
- The use of pesticides and quick-release synthetic fertilizers shall be minimized, and the principles of integrated pest management (IPM) followed. Check with the local jurisdiction for any local policies regarding the use of pesticides and fertilizers.
- Maintain vegetation and the irrigation system. Prune and weed, as needed, to keep the bioretention area neat and orderly in appearance.
- Inspect and, if needed, replace mulch before the wet season begins. Mulch should be replaced when erosion is evident or when the bioretention area begins to look unattractive. The entire area may need mulch replacement every two to three years, although spot mulching may be sufficient when there are random void areas.

Figure 8-1: Bioretention Area in the City of Fremont

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[1] A bioretention area that is unlined and has a raised underdrain in the underlying rock layer to promote infiltration, as shown in Section 6.1, may also be called a "bioinfiltration area".

FLOW-THROUGH PLANTERS – COMMON MAINTENANCE CONCERNS:

Maintenance objectives include maintaining healthy vegetation at an appropriate size; avoiding clogging; and ensuring the structural integrity of the planter and the proper functioning of inlets, outlets, and the high-flow bypass.

- Conduct a biannual (twice yearly) evaluation of the health of the vegetation and remove and replace any dead or dying plants.
- Treat diseased vegetation, as needed, using preventative and low-toxic measures to the extent possible.
- The use of pesticides and quick-release synthetic fertilizers shall be minimized, and the principles of integrated pest management (IPM) followed. Check with the local jurisdiction for any local policies regarding the use of pesticides and fertilizers.
- Maintain vegetation and the irrigation system. Prune and weed as needed to keep the flow-through planter neat and orderly in appearance. Prune or remove any overgrown plants or shrubs that may interfere with planter operation. Clean up fallen leaves or debris.
- Before the wet season begins, check that the soil is at the appropriate depth to allow water to temporarily pond above the soil surface and is sufficient to effectively filter stormwater. Remove any accumulations of sediment, litter, and debris. Till or replace soil (specify sandy loam), as necessary. Confirm that soil is not clogging and that the planter will drain within 3-4 hours after a storm event. Inspect and, if needed, replenish mulch.
- Inspect planter box periodically, and after storms, to ensure structural integrity of the box and that the planter has not clogged.
- Periodically inspect downspouts from rooftops or sheet flow from paving to ensure that flow to the planter is unimpeded. Remove any debris and repair any damaged pipes. Check splash blocks or rocks and repair, replace or replenish as necessary.
- Periodically inspect the overflow pipe to make sure that it can safely convey excess flows to a storm drain. Repair or replace any damaged or disconnected piping.

Figure 8-2: Flow through planter in the City of Emeryville

TREE WELL FILTERS – COMMON MAINTENANCE CONCERNS:

Some manufacturers require a maintenance agreement, under which the manufacturer conducts the maintenance. The following maintenance requirements are typical:

- Conduct a biannual (twice yearly) evaluation of the health of trees and any ground cover. Remove any dead, dying, or missing vegetation.
- Treat diseased vegetation, as needed, using preventative and low-toxic measures to the extent possible.
- The use of pesticides and quick-release synthetic fertilizers shall be minimized, and the principles of integrated pest management (IPM) followed. Check with the local jurisdiction for any local policies regarding the use of pesticides and fertilizers.
- Maintain vegetation and the irrigation system. Prune and weed as needed to keep the tree well filter neat and orderly in appearance. Clean up fallen leaves or debris.
- Before the wet season begins, check that the media is at the appropriate depth. Remove any accumulations of sediment, litter, and debris. Confirm that the tree well filter is not clogging and will drain per design specifications. Till or replace the media as necessary.
- Inspect tree well filter periodically, and after storms, to ensure that it has not clogged.
- Periodically inspect the overflow pipe to make sure that it can safely convey excess flows to a storm drain. Repair or replace any damaged or disconnected piping.

Figure 8-3: Series of non-proprietary tree well filters installed along roadway, City of Fremont

VEGETATED BUFFER STRIPS – COMMON MAINTENANCE CONCERNS:

Vegetated buffer strips mainly require vegetation management. Typical maintenance requirements are as follow:

- Mow and irrigate during dry weather to the extent necessary to keep vegetation alive. Where six-inch high grasses are used, the grass height shall be at least three inches after mowing. Where mowed grasses are shown on the plans, the grass shall be mowed when the height exceeds three inches. Dispose of grass clippings properly.
- Remove obstructions and trash from the vegetated buffer strip.
- Conduct monthly inspections as follows:
  - Inspect vegetated buffer strip for and remove obstructions and trash,
  - Confirm that any ponded flow drains within five days after a rainfall event. If ponding is observed for longer than five days, grading is required to improve positive drainage.
  - Confirm that grasses are in good condition.
  - Identify and correct any erosion problems.
- The use of pesticides and quick-release synthetic fertilizers shall be minimized, and the principles of integrated pest management (IPM) followed. Check with the local jurisdiction for any local policies regarding the use of pesticides and fertilizers.

Figure 8-4: Vegetated Buffer Strip (Source: California Stormwater Quality Association, 2003)

INFILTRATION TRENCHES – COMMON MAINTENANCE CONCERNS:

The primary maintenance objective is to prevent clogging, which may lead to trench failure. Typical inspection and maintenance tasks are as follows:

- Inspect infiltration trench after large storm events and remove any accumulated debris or material.
- Check the observation well 2 to 3 days after storms to confirm drainage.
- Repair any erosion at inflow or overflow structures.
- Conduct thorough inspection annually, including monitoring of the observation well to confirm that the trench is draining within the specified time.
- Trenches with filter fabric should be inspected annually for sediment deposits by removing a small section of the top layer.
- If inspection indicates that the trench is partially or completely clogged, it shall be restored to its design condition.
- Mow and trim vegetation around the trench as needed to maintain a neat and orderly appearance.
- The use of pesticides and quick-release synthetic fertilizers shall be minimized, and the principles of integrated pest management (IPM) followed. Check with the local jurisdiction for any local policies regarding the use of pesticides and fertilizers.
- Routinely remove trash, grass clippings and other debris from the trench perimeter and dispose of these materials properly. Trees or other large vegetation should be prevented from growing adjacent to the trench to prevent damage to the trench.

Figure 8-5: Infiltration Trench (Source: California Stormwater Quality Association)

EXTENDED DETENTION BASINS – COMMON MAINTENANCE CONCERNS:

Primary maintenance activities include vegetation management and sediment removal, although mosquito control is a concern in extended detention basins that are designed to include pools of standing water. The typical maintenance requirements include:

- Maintenance activities at the bottom of the basin shall NOT be performed with heavy equipment, which would compact the soil and limit infiltration.
- Harvest vegetation annually, during the summer.
- Trim vegetation at beginning and end of the wet season and inspect monthly to prevent establishment of woody vegetation and for aesthetic and mosquito control reasons.
- The use of pesticides and quick-release synthetic fertilizers shall be minimized, and the principles of integrated pest management (IPM) followed. Check with the local jurisdiction for any local policies regarding the use of pesticides and fertilizers.
- Conduct a biannual (twice yearly) evaluation of the health of the vegetation and remove and replace any dead or dying plants.
- Conduct semiannual inspection as follows
  - Inspect the outlet, embankments, dikes, berms, and side slopes for structural integrity and signs of erosion.
  - Examine outlets and overflow structures and remove any debris plugging the outlets. Identify and minimize any sources of sediment and debris. Check rocks or other erosion control and replace, if necessary.
  - Check inlets to make sure piping is intact and not plugged. Remove accumulated sediment and debris near the inlet.
  - Inspect for standing water and correct any problems that prevent the extended detention basin from draining as designed.
  - If you observe mosquito larvae, contact Alameda County Mosquito Abatement District, 510/783-7744. (In Albany, Alameda County Vector Control District, 510/567-6800.)
  - Check for slope stability and the presence of rodent burrows. Fill in any holes detected in the side slopes.
  - Inspect for and remove any trash and debris.
  - Confirm that any fences around the facility are secure.
  - Check for sediment accumulation.
- Remove sediment from the forebay when the sediment level reaches the level shown on the fixed vertical sediment marker.
- Remove accumulated sediment and regrade about every 10 years or when the accumulated sediment volume exceeds 10 percent of the basin volume.
- Remove accumulated trash and debris from the basin at the middle and end of wet season (January and April), or as needed.

Figure 8-6: Extended Detention Basin, Palo Alto

PERVIOUS CONCRETE AND ASPHALT – COMMON MAINTENANCE CONCERNS:

Standards for Ongoing Maintenance and Upkeep:

- Keep landscaped areas well maintained.
- Prevent soil from washing on to the pavement. Pervious pavement surface shall be vacuum cleaned using commercially available sweeping machines at following times:
  - End of winter (April)
  - Mid-summer (July / August)
  - After autumn leaf-fall (November)
- Inspect outlets yearly, preferably before wet season. Remove accumulated trash/debris.
- When vacuum cleaning, inspect pervious paving for any signs of hydraulic failure.

As needed maintenance:

- If routine cleaning does not restore infiltration rates, then reconstruction of part of the pervious surface may be required.
- The surface area affected by hydraulic failure should be lifted, if possible, for inspection of the internal materials to identify the location and extent of the blockage.
- Surface materials should be lifted and replaced after brush cleaning. Geotextiles may need complete replacement.
- Sub-surface layers may need cleaning and replacing.
- Removed silts may need to be disposed of as controlled waste.

Figure 8-7: Parking Lot with Pervious Pavement, Emeryville

TURF BLOCK AND PERMEABLE JOINT PAVERS – COMMON MAINTENANCE CONCERNS:

Routine maintenance:

- Keep landscaped areas well maintained.
- The surface of the unplanted turf block and permeable joint pavers shall be vacuum cleaned (if joints are tight, i.e., no sand filling) using commercially available sweeping machines at the following times:
  - End of winter (April)
  - Mid-summer (July / August)
  - After autumn leaf-fall (November)
- Planted turf block can be mowed, as needed.
- Inspect outlets yearly, preferably before the wet season. Remove accumulated trash and debris.
- When vacuum cleaning is conducted, inspect turf block and permeable joint pavers for any signs of hydraulic failure.

As needed maintenance:

- If routine cleaning does not restore infiltration rates, then reconstruction of the pervious surface area that is not infiltrating is required.
- The surface area affected by hydraulic failure should be lifted, if possible, for inspection of the internal materials to identify the location and extent of the blockage.
- Surface materials should be lifted and replaced if damaged by brush (or abrasive) cleaning.
- Sub-surface layers may need periodic cleaning and replacing.
- Deposits may need to be disposed of as controlled waste.
- Replace permable joint materials, as necessary.

Figure 8-8: Turf block fire access (Source: City of Pleasanton)

RAINWATER HARVESTING AND USE – COMMON MAINTENANCE CONCERNS:

Routine maintenance:

- Conduct annual inspections of backflow prevention systems.
- If rainwater is provided for indoor use, conduct annual water quality testing.
- Clean gutters and first-flush devices at least annually, and as needed, to prevent clogging.
- Conduct regular inspection and replacement of treatment system components, such as filters and UV lights.
- If the system includes a roof washer, regularly inspect and clean the roof washer to avoid clogging.
- Regularly inspect for and repair leaks.
- Maintenance requirements specific to cisterns:
    - Flush cisterns annually to remove sediment.
    - For buried structures, vacuum removal of sediment is required.
    - Brush the inside surfaces and thoroughly disinfect twice per year.
- Maintenance requirements specific to rain barrels
    - Inspect rain barrels four times per year and after major storms
    - Remove debris from screens as needed.
    - Replace screens, spigots, downspouts, and rain leaders as needed.

Figure 8-9: Rainwater harvesting system, Mills College, Oakland

MEDIA FILTERS – COMMON MAINTENANCE CONCERNS:

Follow manufacturer requirements for maintenance. Clogging is the primary maintenance concern for media filters, although mosquito control is also an issue. Typical maintenance requirements are as follows:

- During the wet season, inspect periodically for standing water, sediment, trash and debris, and to identify potential problems.
- Remove accumulated trash and debris in the sedimentation basin, from the riser pipe, and the filter bed during routine inspections.
- Inspect the media filter once during the wet season after a large rain event to determine whether the facility is draining completely within five days.
- If the facility drain time exceeds five days, remove the top 50 millimeters (2 inches) of sand and dispose of sediment. Restore media depth to 450 millimeters (18 inches) when overall media depth drops to 300 millimeters (12 inches).

Chapter

9

Alternative Compliance

This chapter provides information on using Alternative Compliance options where LID treatment is required.

9.1 What Is Alternative Compliance?

Provision C.3.e of the Municipal Regional Stormwater Permit (MRP) allows municipalities to grant "alternative compliance" to new development or redevelopment projects in lieu of requiring full onsite treatment of the Provision C.3.d amount of stormwater runoff and pollutant loads with low-impact development (LID) measures. ***Projects that receive alternative compliance must still provide LID treatment in full,*** but all of the treatment does not have to take place onsite. There are no special eligibility criteria for using alternative compliance. If your project is required to provide LID treatment, it may use alternative compliance to meet these requirements. There is no requirement to make LID impracticability or infeasibility findings in order to use alternative compliance. The MRP offers two options for using alternative compliance, described in Section 9.2, sets deadlines for constructing offsite alternative compliance projects (Section 9.3), and sets a timeline for the alternative compliance provision to take effect.

9.2 Categories of Alternative Compliance

A project may use either of the alternative compliance options listed below.

9.2.1 Option 1: Partial LID treatment at an off-site location

Projects may treat a portion of the required amount of stormwater runoff using LID on-site (or offsite at a "joint treatment facility" that is shared with an adjoining project), and then ***treat the remaining portion of runoff at an offsite project*** within the same watershed. Offsite LID treatment measures must provide an equivalent quantity of hydraulically-sized treatment of both stormwater runoff and pollutant loads and achieve a net environmental benefit.

JOINT TREATMENT FACILITY

A joint treatment facility ***treats the stormwater from more than one property*** at an offsite but nearby location.

OFFSITE EQUIVALENT TREATMENT PROJECT

An offsite equivalent treatment project provides off-site LID treatment for a surface area or volume and pollutant loading of storm water run off, equivalent to that of the proposed new development or redevelopment project for which alternative compliance is sought. Examples of acceptable equivalent treatment projects include the installation of hydraulically-sized LID treatment measures in a nearby parking lot, or other development where hydraulically-sized LID treatment measures were not previously installed.

9.2.2 Option 2: Payment of in-lieu fees

Projects may treat a portion of the required amount of stormwater runoff using LID on-site or offsite at a joint treatment facility and ***pay equivalent in-lieu fees to treat the remaining amount*** of stormwater runoff with LID treatment measures at a Regional Project.

IN-LIEU FEES

In-lieu fees provide the monetary amount necessary to treat an equivalent quantity of stormwater runoff and pollutant loading with hydraulically-sized LID treatment measures at a Regional Project ***and*** the monetary amount necessary to share a proportionate amount of the operation and maintenance costs of the Regional Project.

REGIONAL PROJECT

A regional project is a regional or municipal stormwater treatment facility located in the same watershed as the project seeking alternative compliance.

9.3 Offsite or Regional Project completion deadlines

9.3.1 Timeline for construction of offsite project

Construction of the offsite LID treatment project must be completed by the time the subject project is completed. If the offsite project is not completed in time, the offsite project must, for each additional year up to three years, provide additional treatment of 10% of the required amount of stormwater runoff and pollutant loads. For example, an offsite project completed two years after the subject project would be required to treat, using LID treatment measures, 20% more stormwater runoff and pollutant loads than it would had the offsite project been completed in time.

9.3.2 Timeline for construction of a Regional Project

The regional project must be completed within three years of the subject project. This can be extended to five years only with Regional Water Board approval. In order for the Water Board to grant the extension to five years, the applicant must have demonstrated good-faith efforts to implement the regional project by applying for the necessary permits and having the necessary funds encumbered for project completion.

9.4 When Does the Alternative Compliance Provision Take Effect?

The use of alternative compliance is optional, but if it is used, the projects must comply with the MRP requirements for implementing alternative compliance ***beginning December 1, 2011***. Any private projects deemed complete before December 1, 2009, that incorporated alternative compliance under the previous municipal stormwater permit are not subject to the MRP requirements for alternative compliance, if the project has been diligently pursued[1] by the project applicant. The requirements for Alternative Compliance do not apply to public projects for which funding has been committed and construction is scheduled to begin by December 1, 2012.

[1] Diligent pursuance may be demonstrated by the project applicant's submittal of supplemental information to the original application, plans, or other documents required for any necessary approvals of the project.

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